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THE CIVIL SERVANT IN BRITAIN

THE famous report on the organization of the permanent Civil Service signed by Stafford H. Northcote and C. E. Trevelyan was presented to Parliament just over a hundred years ago at the end of February. The anniversary has been marked by numerous articles in the Press, as well as by the publication by H.M. Stationery Office of a booklet reviewing the growth and organization of the Civil Service during a hundred years and by a commemorative lecture before the University of London on February 16, 1954*. In that lecture Prof. K. C. Wheare dealt with the Civil Service in the constitution, with the way in which the reforms recommended in the Northcote–Trevelyan report were effected and some of their implications to-day. Prof. Wheare points out that the centenary of a modern Civil Service recruited and organized on the lines advocated in that report will not be celebrated before 1970, though with the establishment of the Civil Service Commission in 1855 there came into existence a permanent institution with a vested interest in the discovery of merit through competitive examination as a means of entry into the Service. Prof. Wheare is concerned, however, chiefly with the consequences of the adoption of these reforms; he looks upon them from outside the Civil Service and from the point of view of their effect upon the practice and efficiency of government.

The first point to which Prof. Wheare directs attention is one the importance of which has been strikingly emphasized during the past few years. The greatest change in the position of the Civil Service in the constitution since the publication of the Northcote–Trevelyan report does not consist in the removal of patronage or the establishment of permanence. Britain already had a permanent Civil Service, and the Northcote–Trevelyan reforms were aimed at ensuring that those appointed were fit to hold office. The greatest change consists in the increase in the authority of the Civil Service, and this would probably have occurred whether it was recruited by patronage, by qualifying examination or by competitive examination.

Prof. Wheare argues that, whereas a hundred years ago the principal influence in government lay with an aristocracy acting through a cabinet with the advice and consent of Parliament, nowadays the principal influence lies with a bureaucracy acting through a cabinet with the advice and consent of Parliament. This change is due largely to the growth in the extent and intensity of the State's activity and consequent increase in the powers of the Civil Service. So far as the Northcote–Trevelyan reforms have contributed, it is because when increased authority was given to the executive branch, those reforms had provided officers ready and capable of exercising power. Northcote and Trevelyan saw the Civil Service as an efficient body of permanent

* The Civil Service in the Constitution. By Prof. K. C. Wheare. (A lecture delivered before the University of London, on 16 February 1954, to commemorate the centenary of the Northcote–Trevelyan Report.) Pp. ii+34. (London: The Athlone Press, 1954. Distributed by Constable and Co., Ltd.) 2s. 6d. net.

officers occupying a position duly subordinate to that of the Ministers who are directly responsible to the Crown and to Parliament, yet possessing sufficient independence, character, ability and experience to be able to advise, assist and, to some extent, influence those who are from time to time set over them. They saw, in fact, exactly the kind of man that, on one hand, Sir Edward Bridge depicts in his "Portrait of a Civil Servant", and Mr. Herbert Morrison, on the other, in his "Government and Parliament: a Survey from the Inside"*.

Mr. Morrison writes frankly and with understanding about the relations between Civil servants and Ministers, and concludes with an unqualified tribute to the energy, ability, resourcefulness and incorruptibility of the Civil Service, as well as its loyalty to the Government of the day; but he fails to recognize the change to which Prof. Wheare directs attention, and the danger implicit in that change. That may well be because, although Mr. Morrison is expressing an inside view, it is one from the Ministerial angle. He recognizes fairly enough the danger to the public interest that lies in overworking the higher Civil servant and that, like other senior professional men and women, senior Civil servants, though loyal, may not be quick enough in accepting or adapting themselves to new ideas. He has not quite recognized the 'statesman in disguise' of Sir James Stephen; the latter, admitting the evils of patronage and the need for a better-educated Civil servant, nevertheless thought that the man at the top of the examination list would be too good for the Civil Service.

Prof. Wheare puts besides Sir James Stephen's comment of a hundred years earlier the official description, by the Civil Service Commission, of what it expects to-day of a successful candidate for the Administrative Class, and of what he may expect of the Civil Service. He is "concerned with the formulation of policy, with the co-ordination and improvement of government machinery, and with the general administration and control of Departments. The ideal candidate would possess intellectual ability of a high order, and the ability to discern and analyse the essentials of complicated questions, and to express himself with lucidity in speech and writing. He would be able to get on well with all kinds of people, be adaptable, far-sighted and persevering, and have enough strength of character and leadership to hold his own, take decisions and exercise responsibility. He would have enough practical imagination to enable him to devise, in broad outline, workable plans for dealing with an unprecedented situation. Above all, he would need judgment and commonsense".

Before we consider the implications for to-day of a Parliamentary bureaucracy, which has in fact, contrary to some predictions, attracted a high proportion of the ablest young people of successive generations, and perhaps an excessive proportion, one consideration emphasized by Prof. Wheare should be noted. He believes that an important factor in attracting so many of the ablest young people from the schools and universities has been the persistence of the tradition that service to the State is an honourable profession. Prof. Wheare wonders whether that tradition is now as strong as it was. Certainly the tendency of a certain section of the Press to denigrate the Civil Service on any possible pretext, though not countenanced either by Parliament or Ministers, does not help to maintain the tradition. None, however, who is concerned to see that the task of government is well and efficiently discharged can be indifferent to the firm maintenance of the great tradition that has made the Civil Service a pre-eminent profession in Britain.

Prof. Wheare has no hesitation in affirming that to-day we need (and in large measure we get) in the higher Civil Service not only skill in the management of public affairs but also the wisdom, vision and imagination which are the mark of statesmanship, and that it should be the constant anxiety of those responsible for recruitment to see that our methods of selection, training and promotion attract and retain persons possessing such qualities. But he adds two qualifications. First, although in one sense it is true that adoption of the principles of the Northcote–Trevelyan report both took party politics out of the Civil Service and the Civil Service out of politics, a Civil servant's work is carried out in the midst of party politics. Everything he does is done in the name and upon the responsibility of a Minister who belongs to a party, and anything he does may have party consequences for his Minister and, at times, for the Ministry as a whole. In formulating policy, for example, a higher Civil servant is advising and assisting a Minister not only to carry through a policy which is that of a political party with a majority in the House of Commons, but also to defend that policy against the criticisms and attacks of the Opposition.

Accordingly, as Prof. Wheare points out, a higher Civil servant requires a political sense; and in saying this he has put his finger on one of the causes of the mismanagement which has aroused such widespread concern over the Crichel Down report. The essential question in that unhappy episode is what is the public interest, and how and by whom it should be determined. Those questions cannot be answered even by men of the most impeccable integrity or intellectual ability without political sense. Lacking that sense, the extreme delicacy of the position of the Civil servant, of which Prof. Wheare reminds us, is fatally disturbed; but it is equally true that the maintenance of that delicate position depends as much or more upon a correct attitude on the part of Ministers and Members of Parliament towards Civil servants as it does upon the attitude of Civil servants towards them.

On this question of the relations between a Minister and his Department and between Parliament and the Civil Service, one would have welcomed much more comment from one writing from inside, like Mr. Morrison, particularly from one who possesses such a sense of the rights of the House of Commons as a whole and of the responsibility of the Government

* Government and Parliament: a Survey from the Inside. By Herbert Morrison. Pp. v+363. (London: Oxford University Press, 1954.) 21s.

to the House rather than to a political party, and who recognizes the danger that party discipline may be overdone. A concrete episode like that of Crichel Down throws a more searching light on the weaknesses of our Parliamentary institutions and the changes required to adapt them effectively to the needs of to-day than Mr. Morrison's generalizations. Indeed, Prof. Wheare's second proviso is more relevant to the Crichel Down episode than any passage in Mr. Morrison's book. "Civil servants," he writes, "may be statesmen in disguise, but they must not be Ministers in disguise."

Prof. Wheare recognizes that it is possible that Civil servants accustomed to act on behalf of or in the name of Ministers may be tempted at times to think and act as if they were Ministers. He is, however, convinced that it is still an axiom in the Civil Service that no matter how much a Civil servant may act on behalf of his Minister, he must never forget that his Minister bears the responsibility, and for justification of that confidence Prof. Wheare points to the evidence of 'question time' in the House of Commons. The remedy for arbitrariness and errors of judgment such as the Crichel Down report has exposed lies, in Prof. Wheare's view, in stronger Ministers and a more independent and vigilant House of Commons rather than in weaker Civil servants.

Now, although the position of the scientific Civil servant or of the scientific expert in general is nowhere specifically discussed by Prof. Wheare or even by Mr. Morrison, in spite of a brief recapitulation of steps he took, as Lord President of the Council, to improve the arrangements for scientific advice, the nature of the relations between Ministers and their advisers is of vital importance to the participation of the man of science in the task of government. The first condition for effective relations is mutual confidence, and here the question of the relations between Government and Parliament and the dominance of a political majority are more important than Mr. Morrison suggests. Civil liberty depends on Parliament never becoming the instrument of a single class. It also depends on Ministers seeking to further primarily the public interest, and not simply that of a political party which may or may not even represent the majority of an electorate, however much the Ministerial conception of the public interest may be influenced by political ideas. The expert must at least have some assurance that the advice he renders in his particular field will be fairly considered by those competent to appreciate its significance, and that it will be evaluated objectively along with the other factors involved in the situation.

It is because there have been frequent indications in recent years of the plain disregard of facts and of deteriorating standards of Ministerial conduct that the situation cannot be regarded with the satisfaction that Mr. Morrison's book implies. Some five years ago, we commented on two instances which seriously prejudiced the self-respecting association of the scientific and technical expert in the task of government (see *Nature*, **164**, 1103; 1949). Others are to be found since in such matters as fuel policy, broadcasting and television, national parks, and in scientific and industrial research as well as in technological education.

The first step to establish full confidence and proper relations between Ministers and their Departments and advisers, whether scientific or otherwise, is firmly to re-establish the rule affirmed by the Newton National Civil Aviation Consultative Committee in 1948, that no man should be judge in his own case. That indeed is the first thing that should have come out of the discussion in Parliament of the Crichel Down report if any public confidence is to be felt that there will be an end to departmental high-handedness. Failure to elicit such an assurance would have dealt a fatal blow to the essential spirit of the British constitution as well appears from Sir Alfred Denning's lectures, "The Changing Law" (Pp. 122. (London: Stevens and Sons, Ltd., 1953.) 10*s*. 6*d*.). Nor will confidence be restored by an investigation by the Civil Service Committee under Sir Edward Bridge's chairmanship—a Committee which *ipso facto* infringes that principle.

Next, it has to be admitted that the efficiency and possibility of government depend upon removing a great many decisions from the range of popular choice. When the size of a Department compels extensive delegation of power, responsibility must go with it; otherwise petty tyranny and bureaucracy will replace democracy and government by consent. The doctrine of Ministerial responsibility requires re-examination in the context of situations in which it is clear that advice has not been tendered and considered at anywhere near Ministerial level.

This, then, and the indication of the right and force of public criticism were the first things required of Parliament in the Crichel Down debate: they transcend in public importance even any steps taken to rectify an injustice. But of equal importance are the questions what is the public interest, and how and by whom should it be determined. Manifestly, the assumption that every public servant has a primary concern for the public interest and can be trusted without inquiry to pursue it can no longer be accepted. It never has been accepted for the scientific or technical expert, and it is perhaps all to the good that it should now be shown so plainly that the administrator stands on the same level.

It is no longer possible to ignore the evidence which has accumulated since the War, especially over land for the Services and other government departments or public corporations, that a government department is not necessarily any sounder judge of the public interest than anyone else. Decision as to what is the public interest can only be made at ministerial- or even at cabinet-level. If the cabinet fails to formulate the broad lines of policy and it is impracticable or impossible for a Minister to master all the facts and details in the multitude of cases in which this principle would reserve to him the final decision, we have to evolve some further practical means, as Sir Alfred Denning indicates, of providing that the issues are surveyed impartially at some stage by a competent but wholly independent person.

That is the vital principle at stake and Parliament has no greater responsibility than to insist on seeing that the means necessary to serve it are implemented without delay. It affects almost every aspect not only of the impact of government and of the Civil Service on the lives of the individual citizen, but also of the participation of the man of science and the technical expert in the task of government. To them it would offer the assurance, not yet wholly theirs, that the advice they tender within their own particular field of competence and knowledge would be considered intelligently and impartially along with that given by other experts concerned, and evaluated in the light of the situation as a whole. More they are not entitled, nor do they wish, to claim. But such measures for terminating the power of a government department or any other body to judge its own cause, and giving the assurance of impartial consideration of all issues and fair treatment of individuals, would have as one further consequence the placing of the scientific and technical expert more nearly on an equality with the administrator. Their importance justifies the hope that they will be formulated in no party spirit, but with full appreciation of how much is at stake—no less than the stability of our Parliamentary institutions.

In the debate in the House of Commons on July 20, the doctrine of ministerial responsibility was supported not only by the resignation of Sir Thomas Dugdale but also on all sides of the House. There was some general appreciation of the complexities that arise in applying that doctrine to-day. More might have been said on the question of the public interest; but the swiftness with which Sir John Woods's Committee has reported to the Prime Minister and the forthrightness of the report on this point warrant the hope that these issues will receive ample and urgent attention. "In the present times," says the report, "the interests of the private citizen are affected to a great extent by the actions of Civil Servants. It is the more necessary that the Civil Servant should bear constantly in mind that the private citizen has a right to expect, not only that his affairs will be dealt with effectively and expeditiously, but also that his personal feelings, no less than his rights as an individual, will be sympathetically and fairly considered." It is a prime responsibility of Parliament to see that that doctrine is never forgotten or ignored.

EXPERIMENT IN THE POPULARIZATION OF SCIENCE

Die Welt der ungewohnten Dimensionen
Versuch einer gemeinverständlichen Darstellung der modernen Physik und ihrer philosophischen Folgerungen. Von Prof. Arnold Hildesheimer. Pp. 368. (Leiden: A. W. Sijthoff's Uitgeversmaatschappij N.V., 1953.) 17.90 Dutch florins.

TRANSLATED into English, the title of this four hundred-page volume by Prof. Arnold Hildesheimer is "The World of Unaccustomed Dimensions". Its scope is, however, more closely defined by the sub-title: 'Versuch' of a popular presentation of modern physics and its philosophical implications. 'Versuch' could mean one of two things: 'attempt' or 'experiment'. Regarding the work as an attempt, the reader is immediately captivated by the enthusiastic earnestness of the author's endeavour to raze the mathematical fortifications separating the 'expert' from the interested layman, in order to open for him a view into the fundamental concepts of physics and all their enjoyable or threatening technical consequences with which modern man has to live. The author points correctly to the abyss which isolates the scientist from the masses. Any attempt to bridge this gap will be greatly appreciated by anyone living on either side of the fence, and throughout the book the honesty of this attempt can be recognized.

In four main parts, the author tries to encompass the essential ideas in physics as they have evolved during the past five centuries. In the first part, dealing with "The World of Medium Dimensions", we get a rapid treatment of classical mechanics, the field concept, matter, gravitation, energy, causality, statistics, entropy, the atom, optics and Maxwell's theory of electromagnetism. The theory of relativity is introduced in the second part: "The Macrocosm". Both special and general relativity are discussed, and the author tries to familiarize the reader with four-dimensional geometry and Riemann spaces. Part 3 turns to "The Microcosm". Quantum and wave mechanics are described in terms of the work of the great leaders, Planck, Bohr, de Broglie, Schrödinger and Heisenberg, and the duality wave-particle is pointed out. In the fourth and final part, "Consequences for the Theory of Knowledge", the author summarizes and integrates the concepts presented and speculates about the significance of these thoughts for the ultimate issues like fate, free will, *existentia et essentia*. A bibliography of more than sixty popular and scientific books on these subjects and eight appendixes plus a complete index conclude the book. On every page the author's admiration for the giants is evident, and wherever it is feasible he allows the great men of science to speak in their own words.

No doubt this work represents an honest attempt to relieve the layman from his 'sacred awe' when he is exposed to the innermost of the magic circles of science. But the question is: What is the result of the work as an experiment? In other words, how successful has the author been in explaining to the layman the essential pillars of scientific thought? How much does he contribute to the clarification of complex ideas like curvature of space, entropy and probability, the uncertainty principle and similar concepts? This brings us to the method the author uses throughout the whole book: the method of comparison.

Almost every page contains one or more examples in which a physical situation is 'explained' by a comparison with simple everyday-life experiences. If some of these comparisons contain words which perhaps are not in the vocabulary of the reader, the first-order comparison is explained by a second-order comparison with an even more simple everyday-life experience—and so on. This leads to a hotchpotch of armchairs, gravitational fields, pregnant mammals, cosmologies, twirling sticks, cannons, Maxwells, horse carriages, Jacks and Jills, red shifts of spectral lines, flying bullets, pilots jumping off planes, potential barriers, Riemann spaces and people invited to parties. It finally becomes so complicated that not only does the

reader lose completely the thread of what had to be explained in the first place, but the author is also deeply lost in an ocean of n-th order explanations. Furthermore, it is doubtful whether an everyday experience can suffice to serve as an analogy to atomic or cosmic situations. If that were the case, quantum mechanics and general relativity could be reduced to classical mechanics. The poetic comparison of a beautiful girl with a rosebud is perfectly legitimate if one knows both. But it is doubtful whether somebody who has never seen a girl would recognize one as such, if he only knows that they are like rosebuds.

It can be argued that the interested layman may suddenly grasp the idea of the metric tensor if he is told that if one invites people (stars) to a party (universe) and they have to bring chairs (gravitational fields) along, it may eventually become so crowded that a newcomer may indirectly cause a distant guest to move his chair (the distribution of the masses in the universe defines the geometry of the universe—pp. 175 and 185). But it cannot be argued that the author's statement ". . . the formula $v=\lambda\nu$ tells you, as you know, that the velocity of a wave is solely dependent upon the medium in which it is propagated. . . ." is wrong (p. 99). Another example: ". . . If one observes the light of a body in its spectrum and recognizes that this spectrum has shifted to the red, one has proof that the frequency of the light is reduced, i.e., the motion of the body has been retarded. And indeed that is observed if one views in the spectrum the β-rays emitted from a rapidly moving radium atom. . . . This redshift of the spectrum is one of the proofs of Einstein's theory of light" (p. 149). This statement is not only wrong, it is nonsensical, like "the causal law of gravitation" (p. 305). Misinterpretations of the type of 'near-truths' occur frequently in the book. This is a consequence of the hopeless attempt to describe the rules of chess by those of noughts and crosses. Readers who may look for some hints in the field of nuclear physics will be disappointed. The word meson is mentioned only once, and the all-out effort of modern physicists to determine the structure of the nucleus is not mentioned once.

If this honest attempt at a popular presentation of modern physics and its philosophical implications is regarded as an experiment in popularization, I must regretfully conclude that it is a failure. But the question remains: Can science be popularized at all?

HEINZ VON FOERSTER

MODERN FOOD HYGIENE

Food Poisoning and Food Hygiene

By Dr. Betty C. Hobbs. Pp. x+174. (London: Edward Arnold and Co., 1953.) 14*s*. net.

THIS book by Dr. Betty C. Hobbs should be read by all those interested or engaged in the production and handling of food. It will also be found of great use to those who are engaged in the administration of the new Food and Drugs Act in its present and anticipated amplified form.

At any time the contents of the book would be a valuable contribution to the literature of the subject; but its publication now enhances its value. As its title implies, it deals with the subject in two sections —food poisoning and food hygiene—and it is written in a manner which makes it easily understood by others than specialists. There is a tendency to deal with the subjects rather more from the academic than the practical aspects, and only those who have experienced the great difficulties of administering the simple rules of food hygiene will grasp how practically impossible it will be to carry out *in toto* the recommendations in Dr. Hobbs's book, admirable as they are.

The simple explanations and clear illustrations in the section dealing with food poisoning should convey to the reader something of the complexity of the subject, and the manner in which these micro-organisms form the toxins. Until very recently, *Clostridium welchii* were not regarded as falling into the class of food-poisoning bacteria, but, according to the table on p. 36, they were the cause of the outbreak of twenty cases out of a total of thirty-three. In the pages following these tables, explanations are given of the history of these cases, and these need to be read in the light of the second section of the book, dealing with hygiene. In this, there is sound advice, which, if it can be followed, should do much to minimize these outbreaks; but it is not all easy to carry out.

The female's head-covering, illustrated on p. 85, is not effective; experience has shown that the hair must be completely covered. The idea of regular educational talks on personal hygiene, although by no means new, is an excellent one; but it will be found that, in order to secure a full audience, such lectures have to be delivered during working hours and, therefore, interfere with production. It is a pity that Dr. Hobbs fails to direct attention to the hazards attached to the cafeterias of the help-yourself type, in which the unwrapped food is exposed to fingering, coughing and sneezing by hundreds of persons every day. Perhaps greater attention could be focused upon the cause of contamination of foods in retail shops, due to exposure, unclean knives, soiled aprons, etc., and the fly menace.

Dr. Hobbs is to be congratulated upon the excellence of her book. It should certainly enjoy a wide circulation, and it will doubtless prove of great use to the food industry.

OSMAN JONES

EXPERIMENTAL PLANT MORPHOLOGY

Entwicklungs- und Bewegungsphysiologie der Pflanze

Von Dr. Erwin Bünning. Dritte auflage. (Lehrbuch der Pflanzenphysiologie, Zweiter und Dritter Band.) Pp. xii+539. (Berlin: Springer Verlag, 1953.) 49.60 D. marks.

EXPERIMENTAL plant morphology has recently undergone a revival, especially in Germany, and there are flourishing research schools under Richard Harder in Göttingen and Erwin Bünning in Tübingen. Indeed, Bünning's monograph, which is here under review in its third edition, is a monumental summary of the subject, and a valuable source-book of facts and ideas.

Particularly ideas. For if there is one criticism of this book it is that the documentation of facts is inadequate and the distinction between established facts and illuminating speculation is not always clear. The expression "dass wird man so und so erklären können" is admirable when the speaker can

be cross-questioned about the authenticity of his facts: it is exasperating when the reader has to guess whether this *is* the explanation, or only whether it *might well be* the explanation. A symptom of this failing is the paucity of references (though there are many more than there were in the second edition) and the absence of an author index.

The book has been enlarged by some seventy-five pages, mostly by the interpolation of new paragraphs. Its scope remains as it was: chapters on growth and cell division, differentiation (with a considerable amount of new material), plant movements, and the effects of external stimuli on movement and development. Bünning's own views on photoperiodism and endogenous rhythms are well summarized, together with recent experiments which appear to corroborate his hypothesis.

In a book which covers such a wide sweep of knowledge any critic can find omissions; a few of them are mentioned here only in the hope that they may be repaired in a fourth edition. The discussion of the relation between respiration and growth (pp. 84–91) is not convincing, and needs fuller and more critical treatment. The section on weed killers (p. 132) might well be expanded, for it omits so much that it is not easy to understand the residue. The section on stomatal movement (p. 429) is not up to date. Vernalization (p. 473) receives a scant three and a half pages, which seem inadequate in a book which specializes in developmental physiology. Finally, one is bound to say that the style suffers from a Teutonic turgidity, and the index is not nearly full enough for an important work of reference of this kind.

However, these are criticisms of detail, and they do not detract seriously from the massive erudition of the book and the fecundity of its ideas. It cannot be denied that the most powerful weapons in plant physiology are the techniques of physics and chemistry, and that sooner or later every physiological problem needs these weapons for its solution. But as more mature physiological problems reach the stage which requires the chemist's technique, new problems emerge from the experience of naturalists and gardeners and agriculturists; and these can be tackled by the techniques of biology. Anyone who doubts such an assertion as this has only to read Bünning's book. For the English student, who is likely to hear all too little of this fascinating field of physiology, the book has a great deal to offer, and it is to be hoped that sooner or later an English translation will be available.

E. Ashby

THE RARER METAL, ZIRCONIUM

Zirconium

By Dr. G. L. Miller. (Metallurgy of the Rarer Metals No. 2.) Pp. xviii+382. (London: Butterworths Scientific Publications; New York: Academic Press, Inc., 1954.) 45*s*. net.

THIS book is the outcome of its author's desire to collate the information on zirconium which has been accumulating so rapidly during the past few years. Dr. G. L. Miller has been in an advantageous position to do this by reason of his own wide experience and also because of his visits to workers in the same field in the United States. As a result of his work, he has written this text-book and reference volume which will appeal to every chemist and metallurgist interested in zirconium. There are eighteen chapters, the first of which opens with the history and the occurrence of zirconium, its consumption and uses both as metal and alloys and, naturally, as a refractory material. The treatment in all cases is as thorough as the available data will permit, and the very carefully assembled bibliography at the end of each chapter is up to date and of notable dimensions. Methods of extracting the metal and the preparation of pure zirconium compounds are discussed in some detail, in particular the separation of hafnium and zirconium from one another. Earlier and more recent production methods are described, notably the van Arkel or iodide process and the Kroll processes in which purification and reduction are combined. Reduction of the tetra-chlorides of titanium and zirconium and the arc-dissociation of halides, and also methods of electrodeposition from fused salts as well as from aqueous and non-aqueous solutions, receive attention.

Following a general account of the structure, crystallographic, atomic and nuclear characteristics, attention is given to physical properties. Thermal, electrical, optical, thermionic and magnetic properties are reviewed and illustrated by graphs. There are two chapters on the mechanical properties of zirconium metal, and on zirconium alloys at room and at elevated temperatures. In this latter chapter, alloys of some twenty-four elements are included, not counting the zirconium alloys with oxygen and nitrogen which receive separate treatment in the following chapter. The chemical and corrosion resisting properties of the metal and its alloys and their resistance to the action of liquids in general and to some of the concentrated mineral acids as well as a range of organic acids is illustrated by a series of useful tables. Probably the most valuable and generally useful chapter in the book is that on alloys of zirconium, in which first the alloying theory and its application to zirconium is discussed on a theoretical basis and then the practical results of comparatively recent investigations of binary systems involving zirconium are reported with phase diagrams of many of the binary alloys. This chapter has a bibliography involving more than eighty references and covering all the contemporary useful contributions to the subject. The chapter on melting practices discusses those types of furnace that can be applied to zirconium and is followed by an account of fabricating the metal by rolling, extrusion and other techniques, in which brazing and soldering are not lost sight of and attention is directed to the fact that zirconium has superior wetting and very good bonding qualities.

The powder metallurgy of zirconium has its own chapter in which the conclusions of H. A. Hausner and his colleagues at Sylvania Electric Products, Inc., Bayside, Long Island, New York, that zirconium is readily fabricated by powder methods are confirmed. The most important part of the chapter deals with the preparation of zirconium powder. The last chapter covers special compounds such as the nitride, the carbide, the boride and the silicide, but there is a valuable appendix dealing with some eleven methods of preparing material for metallographic examinations.

The usefulness of the chapter bibliographies is increased by the addition of a final black numeral or numerals to each reference denoting the page upon which the reference is cited, a distinct advantage to the busy worker who quickly wants to find where the reference appears and its specific terms.

H. W. Greenwood

Introduction to Solid State Physics

By Prof. Charles Kittel. Pp. xiii+396. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1953.) 56s. net.

THIS book forms a valuable addition to the literature on solid-state physics, and can be strongly recommended to those engaged in the preparation of university honours degree courses in this subject. The range of subjects included is wide: the sixteen chapters deal with crystallography, elastic, thermal, electric and magnetic properties, the electron theory of metals, and crystal imperfections, problems for the student being suggested at the end of each chapter. Prominence is given to relatively new subjects such as ferroelectricity and antiferromagnetism.

The emphasis is almost entirely on theory; experimental methods are referred to only briefly. A high standard of theoretical ability is expected of the reader, and occasionally the author seems to have taken a delight in starting from unnecessarily general premises. For example, he defines the unit cell of a crystal as a polyhedron, whereas it is always taken to be a parallelepiped; and in equation 1.12 is it fair to the student to allow the same symbol—*i*—to have two different meanings, clear as these may be to the expert?

In fact, the first chapter, on X-ray crystallography, is the weakest in the book, and contains several statements that would not be accepted in crystallographic circles. For example, on p. 9 symmetry elements called rotation-reflexion axes are introduced; they should be rotation-inversion axes. It is hoped that in future editions of the book, Chapter 1 will either be largely rewritten or will consist mainly of references to standard crystallographic text-books.

Yale University Publications in Anthropology

No. 49: Excavations at Wari, Ayacucho, Peru. By Wendell C. Bennett. Pp. 126+12 plates. No. 50: On the Excavation of a Shell Mound at Palo Seco, Trinidad, B.W.I. By J. A. Bullbrook. Pp. 114. (New Haven, Conn.: Yale University Press; London: Oxford University Press, 1953.) 3 dollars.

THIS volume is made up of two papers, each dealing with a particular aspect of American archæology. The first is a posthumous publication of Prof. Wendell C. Bennett, whose premature death last summer deprived South American archæology of one of its most notable scholars. It describes his excavations, in 1950, at an extensive habitation site, spelt variously Wari and Huari, in the little-known but important highland basin of Mantaro, which lies just north-west of the Cuzco basin. The chief remains at Wari are contemporary with the Classic Period at the well-known ceremonial site of Tiahuanaco in Bolivia, with which they have many features in common; but they include a pottery style more closely related than any at Tiahuanaco itself to the Coastal Tiahuanaco style which has such a wide distribution on the coast. Prof. Bennett discusses fully the relationships between the various Tiahuanacoid sites and makes suggestions as to the nature of the contacts between them.

In 1919, Mr. J. A. Bullbrook excavated a shell mound in southern Trinidad with official support, and the resulting material and the report went to the British Museum. Mr. Bullbrook is a geologist with considerable archæological experience, and his work was done very carefully; for various reasons it was not published at the time, and for many years afterwards he got little encouragement. He continued to live in Trinidad, and when members of Yale University began to work on the West Indies about fifteen years ago, his researches came to their notice. Subsequent work, mainly by Dr. Irving Rouse of Yale, has confirmed his results, and Dr. Rouse has considered it worth while to edit the report and publish it in spite of the long interval since it was written. The Palo Seco mound was inhabited at two periods in Pre-Columbian times, separated by a short interval, by people who lived on shell-fish, fish and game, probably with some cultivated plants, although there is no direct evidence of agriculture. There are few artefacts other than pottery, which forms the basis for the definition of one stage, the Palo Seco style, in a succession of rather similar types established by Dr. Rouse. The British West Indies have been very much neglected by archæologists until recently, and most of the modern work has been done by Americans. Mr. Bullbrook's pioneer work, which satisfied the exacting standards of the school at Yale, is much to his credit.

G. H. S. BUSHNELL

Advances in Electronics

Edited by L. Marton. Vol. 5. Pp. xii+420. (New York: Academic Press, Inc.; London: Academic Books, Ltd., 1953.) 9.50 dollars.

ENGINEERS and physicists will again be indebted to Dr. L. Marton for bringing together further review articles in this Vol. 5 of "Advances in Electronics". A wide field of specialization is represented, the most topical of which are colour television and junction transistor applications. Other subjects include thoria emitters, solid-state luminescence, detectors for visible and infra-red radiation, β-ray spectroscopy and modern vacuum pumps. The articles are authoritative, clear, well illustrated and contain abundant references; the cumulative index includes earlier volumes. This book is to be highly recommended.

L. JACOB

Explorers of the Pacific

European and American Discoveries in Polynesia. By Te Rangi Hiroa (Peter H. Buck). (Bernice P. Bishop Museum Special Publication 43.) Pp. viii+126. (Honolulu: Bernice P. Bishop Museum, 1953.) 1.75 dollars.

THIS is a posthumous work which arose apparently out of Sir Peter Buck's monograph, "An Introduction to Polynesian Anthropology". It purports to be an important anthropological document, "for it describes the early contacts of Polynesians with Europeans and Americans, hence provides a picture of the setting in which the culture change of modern times had its origin". What it does is to give a brief account of voyages in the Pacific between 1486 and 1849 in chronological order and without any real attempt to estimate their importance. Some of the brief judgments on the explorers give a wrong impression: for example, that Drake "fooled" the Spaniards by not returning via Magellan's Strait, or that Cook, on his third voyage, "dispelled the theory of a northern passage into the Atlantic". The list of "literature cited" is incomplete as a bibliography, and, although a great many islands are mentioned in the text, there is only one small map on which the main groups of islands are marked. This book has its use as a brief guide to voyages in the Pacific; but is too brief to make any serious contribution to our understanding of any of them.

J. N. L. BAKER

NATURE PROTECTION IN THE NEAR AND MIDDLE EAST

DURING June 3–9 a conference on the conservation of Nature in the Near and Middle East was held at Beirut, organized by Prof. F. Ghosn, president of the Lebanese Society of the Friends of the Trees, and Mr. W. E. Purnell, director of the Unesco Middle East Scientific Co-operation Office. The conference was attended by scientists and others from Cyprus, Egypt, Greece, Iraq, Jordan, Lebanon, Syria and Turkey. Dr. E. H. Graham, director of plant ecology, Soil Conservation Service, United States Department of Agriculture, attended from Washington, D.C., and Lieutenant-Colonel C. L. Boyle went from London on behalf of the Society for the Promotion of Nature Reserves and the Fauna Preservation Society. Many of the participants are actively engaged in conservation problems in their own countries and, at the conference, had an opportunity to exchange opinions and discuss experiments. After a short general discussion, study groups were formed to consider separately soil, flora, fauna and education.

The discussions of the soil and flora groups showed that, although great damage had been done to the forests of the Near and Middle East, they had not been utterly destroyed. M. P. Ballot, head of the French Agricultural Mission to the Lebanon, said that they had only just realized the continued existence in the Anti-Lebanon mountains of a juniper forest of perhaps a million trees; furthermore, experiments had shown how extraordinarily quickly vegetation could re-establish itself when it was protected from grazing. A distinction can be drawn between the damage done by the grazing of sheep and of goats; whereas trees can grow fairly quickly beyond the reach of browsing sheep, goats, as was shown by a photograph of them feeding high in an oak tree, can reach almost anything.

The flora group pointed out that in much of the area the climate is not sufficiently arid to explain the lack of vegetation; but even where the rainfall is adequate, the destruction of the plant cover has resulted in the water being lost by immediate run-off, deep percolation and evaporation. Moreover, it is not only the quantity of plants which matters. Where grazing is heavy, perennial grasses with spreading root systems, which bind together the soil, build up humus beneath the surface and retain moisture, are replaced by annual grasses which do nothing to resist erosion. Similarly, forests are replaced by thorny shrubs with tapering roots, which do little to conserve the soil. The annuals and the thorny shrubs survive because they can resist grazing.

It is fully understood that complete elimination of goats is not possible, for they play an important part in the economy of the area; but their number must be radically reduced. Mr. Y. Salti, director of forests, Jordan, explained how goat control is effected in his country. When a considerable majority in a village vote against goats, they are restricted to three tethered goats per family. In practice, the reduction in goat population is not easy, for it is the shepherds who own not only the goats but also the village rifles.

The chief factor in the destruction of the forests has been the demand for fuel; but preservation is linked with the economic betterment of the people. A man blamed for cutting good, bearing olive trees said, "What am I to do? I have a large family and absolutely nothing with which to provide them with food, but the immediate value of these trees".

Wood is cut for many purposes besides domestic burning—for charcoal burning, for firing of bakeries and lime kilns. That these can be brought under control has been shown by the example of Cyprus. Oil is the alternative to wood, but for domestic use oil alone is of little value. The production of a really cheap crude-oil stove would be a major step towards the prevention of soil erosion. The solar stove, which cooks by the sun's rays, is considered to be a possible answer to the problem, but so far its cost has been prohibitive.

The fauna study group, working under the chairmanship of Prof. C. Kosswig, of Istanbul, were told how the recent killing of pelicans on Lake Marmara has resulted in such competition for food among young carp that their growth has been retarded and none has reached full size. A very interesting report came from Cyprus, where natural regeneration of the forests of *Pinus nigra*, confined to altitudes above four thousand feet, has failed. In spring, when the warm khamsin wind blows, the cones open and discharge their seeds, which, clearly visible on the snow, are eaten by hordes of migratory finches. Possibly destruction of hawks, which controlled the number of finches, has led to the failure of the natural regeneration of the pines.

Egyptian scientists directed attention to the dangers inherent in the excessive use of poison sprays and insisted that nature reserves should contain as many kinds of habitat as possible, including ponds for the protection of water insects. They recommended special protection for the desert monitor and the four large lizards of the genus *Uromastix*, the only herbivorous lizards; these are in danger of extermination because they are being used in laboratory work, for which smaller lizards would do equally well. Stress was laid on the importance of instruction in the mosques, for the fellaheen are very responsive and have great faith in their religious teachers.

Among the recommendations of the fauna group was that a questionnaire should be sent to appropriate schools in Turkey, to discover the status of the rare monk seal, which still appears every year on the coasts. Similar methods in other cases have produced good results. An investigation into the status of the rock hyrax in Lebanon, with the view of its preservation, was also suggested. Many mammals were recommended for protection—for example, the leopard, lynx and jungle cat in Turkey and the wild ass and addax in Egypt, where they still exist on the Sudan border. Reserves for wild life were recommended at Kammouha in the Lebanon, in the province of Lattakia in Syria and at Wadi-el-Natroun and Wadi-el-Assioti in Egypt.

All governments were advised to safeguard rivers against pollution. Though rivers in this part of the world may not yet have been affected, it is a danger to be guarded against as industrialization progresses. Destruction of fish by poison and explosives will

never be stopped until fish wardens are appointed and the public instructed in conservation.

During a visit to the best-known group of cedars in Lebanon, it appears that grazing in their vicinity has been stopped; nevertheless, there was little sign of regeneration, prevented perhaps by human trampling. The conference was shown research work at the Franco–Lebanese agricultural college at Ryak and, on the coast, research into the fixation of sand-dunes by grasses backed by plantation of the umbrella pine, *Pinus pinea*.

A full report of the conference will be prepared by the Unesco Middle East Science Co-operation Office, and suggestions for the implementation of the resolutions sent to appropriate bodies.

C. L. BOYLE

PROGRESS OF CANCER RESEARCH

THE investigations under way at the research centres financed by the British Empire Cancer Campaign are described in its thirty-first annual report*; incidentally, it may be remarked that the Campaign's income in 1953 was £350,000, which is about the cost of one air liner.

The different lines of work surveyed in the report can be grouped into those dealing with: (*a*) carcinogenesis, cytotoxins, nucleoproteins (in the laboratory light-heartedly referred to as 'secret-of-life studies'), tissue culture and immunology; (*b*) radiotherapeutics and radiobiology; (*c*) clinico-pathology.

The explanation for the ominous increase in lung cancer in the past two or three decades continues to be the principal theme of general interest in cancer research.

Emphasis has now shifted slightly from cigarette smoking as a very important factor in the causation of the disease to the influence of atmospheric pollution. This does not mean that experiments on the tobacco factor have ceased; far from it, for at several laboratories mechanical smoking installations have been set up with the aim of obtaining in quantity the components of tobacco smoke and testing them on animals. One of the main problems is, of course, to find an experimental tissue with the same sensitivity as human lung.

Tobacco extracts reinforced by croton oil have failed to induce tumours when applied to mouse skin. The complementary experiment when the extracts were tested as possible co-carcinogen for dimethylbenzanthracene also gave negative results.

The inhalation of carcinogen-loaded charcoal has not induced lung cancer in a single mouse of eighty-five which survived a minimum of six months, although the same charcoal suspension was actively tumour inducing when injected subcutaneously. It is suggested that the negative result is due to the carcinogen not reaching the parenchyma but being rapidly removed from the bronchial tree. This explanation could be confirmed by the fluorescence microscopy of frozen sections.

At the Glasgow centre it was found that application of crude oxidized nicotine to the skin of fourteen mixed-stock mice gave adenomata of the lung in seven of the animals. This remarkable result seems to have induced a hypercritical state in the investigators, Schontal and Head, for they say, "However, these results may not be significant, and should be repeated using a different strain of mice as well as other species of animal".

The part played by industrial and domestic smoke in the causation of lung cancer is discussed in Sir Ernest Kennaway's review of atmospheric pollution in Iceland, Britain and Norway.

"Great Britain has stores of coal and iron which have been the source of vast wealth, and of many other consequences. Iceland, which has no such resources, and has not even abundance of any kind of fuel except peat, has a history, and a degree of civilization which all other countries must admire, without industrialization or poverty as we understand these things in many countries of Europe and America. Hence data from a country such as Iceland are of great value for comparative purposes. The Industrial Revolution which in the earlier part of the 19th century converted England, by the utilization of coal and iron, from an agricultural to an industrial country, caused an enormous increase in atmospheric pollution. Obviously this factor cannot, by itself, account for the sudden increase of deaths attributed to cancer of the lungs which occurred a century later, in the 1920's, when the output of smoke was declining. Recently the greater part of this increase, and the higher incidence of this form of cancer in towns, has been ascribed to tobacco, but a possible contributory effect of the suspended matter of town air cannot yet be excluded finally. Iceland provides the example of a country where bronchial cancer is rare, the general consumption of tobacco small, and atmospheric pollution quite unlike that in England, though the history of Reykjavik is rather confused in this respect, as was pointed out above. In the course of years such comparative studies may enable one to assess the importance of these two factors."

For comparison Sir Ernest quotes figures for smoke estimations in the three countries.

COMPARATIVE MEASUREMENTS OF ATMOSPHERIC POLLUTION

	Smoke, mean mgm. in 100 m.³ air
Sheffield	
February 1948: 3 foggy days	173
" " 25 other days	40
" 1949	44
Salford (Manchester)	
November 1952 to January 1953	76
Leicester	
Whole year	21·5
Oslo	
1953, February, March November	5·5
" April to July	1·7
Reykjavik	
1953, August, September	1·0
" October, November	1·6

The report goes on to say: "In the smoke papers from Salford the following polynuclear hydrocarbons have been identified, and some of these have been estimated quantitatively: anthracene, pyrene, fluoranthene, perylene, 1 : 2-benzpyrene, 3 : 4-benzpyrene, 1 : 12-benzperylene, anthanthrene and possibly an alkyl pyrene and 1 : 2-benzanthracene. The relative proportions of these hydrocarbons, e.g., the ratio pyrene : 3 : 4-benzpyrene, differ in various products of combustion and such comparisons provide an interesting subject for study".

Research at the London Hospital has given some startling results. Croton oil, the best-known co-carcinogen (or promotor), can induce tumours when it is painted on mouse skin, provided the skin has

* British Empire Cancer Campaign. Thirty-first Annual Report covering the Year 1953. Pp. xxxiv+468. (London: British Empire Cancer Campaign, 1954.)

been pretreated by a sub-threshold painting with a carcinogen. It has now been shown that urethane, which is a potent inducer of lung tumour, but is ineffective on skin, can act as an initiator for this tissue, for if croton oil is applied to urethane-treated skin, tumours do in fact arise. These findings have important possibilities, for there is no obvious reason why the urethane–croton oil combination should be unique.

At Leeds, Dmochowsky has found that the C_{57} black strain of mouse which is reputed to be non-susceptible to mammary cancer (incidence of the order of 1 per cent) has now developed a sub-line, the females of which are liable to this disease to the extent of 14 per cent; moreover, these mice now carry the viral milk factor.

The application of physics in the study of the cause and cure of cancer covers each year an ever-widening field, and while the same basic problems remain, they are being considered from an increasing number of directions. The varied use now being made of the fundamental principles involved in scintillation counting is a very good example of the application of new techniques to old problems. Dosimetry, which remains one of the perennial problems facing the medical physicist, is studied by means of probe-type scintillation dosimeters which are now in routine use for the measurement of the γ-radiation dosage-rate, and which are being modified at various centres for use with β-radiation sources and for the measurement of X-radiation. Various improvements in scintillation counters themselves are also reported, such as the increased sensitivity obtained in a collimated system with the use of a long, narrow crystal, the use of a double-probe unit coupled to a pen-recorder for measuring the rate of blood flow after the injection of sodium-24, and the technique of mixing the substance to be assayed with a liquid phosphor, such as one of the terphenyl-in-benzene type.

Radioactive isotopes have become an everyday aid in the study of a very large variety of problems, as well as a standard therapeutic procedure for many malignant conditions. The use of thulium-170 in radiographic work has been continued and a detailed study made of the physical characteristics of this isotope. The possibility of providing a method for the measurement of blood volume based on erythrocytes labelled with chromium-51 has been considered and work is proceeding on the estimation of the chromium-51 by means of its soft X-ray. Therapeutic procedures with radioactive isotopes still continue to receive careful attention as improvements and modifications of techniques are reported from various centres. The increasing use of cobalt-60 beam therapy units has led to studies of the quality of the radiation from the beam in water phantoms and also of the effects due to the presence of bone in the field being irradiated. Comparisons are made of the calculated and measured doses obtained in a model in which bones were embedded in tissue-equivalent wax when irradiated with rays from a cobalt-60 source and with X-rays of half-value layer 1·5 mm. copper and 50 cm. focal skin distance. The question of protection from these and other sources of high-energy radiation is one of particular urgency, and studies are reported of the measurements of both the quantity and quality of the radiation dosage liable to be received by workers in these departments. Education of technical and nursing staff is of importance in this respect, and efforts are being made to reduce the dosage-levels received, by nursing staff in particular, by means of lectures and demonstrations.

Reports on studies of plant interphase nuclei by means of interference microscopy, of the study of the electrophoresis of non-spherical particles, and of the ionophoresis of radioactive phosphate ions, are examples of some of the more unusual applications of physics to biological problems.

The pathological contributions to the report are, as usual, very mixed, whether considered from the point of view of subject, mode of presentation, or value; but they include—also as usual—a number of items of more than ephemeral interest.

The systematic accumulation of data at Great Ormond Street Hospital, London, on the tumours of childhood continues its ponderous but invaluable course. Dr. M. Bodian writes something more like a section of a text-book than a report, but at least the text-book is a good one and one that needs writing. This year's chapters deal with the teratomata, the lymphomata, and the adrenal, cervical and vaginal carcinomata. A discussion of the pathology of sacral teratomata from the point of view of their management in practice, and the identification of the relatively benign paragranuloma in three of seventeen children with Hodgkin's disease are of particular interest. Apart from this, there is a most interesting account from the same centre of the use of vitamin B_{12} in the treatment of neuroblastoma. This was originally used on the hypothesis that it might promote the maturation of neuroblasts to ganglion cells, a process which occasionally results in the spontaneous arrest of these tumours. No direct support for the truth of this hypothesis has been obtained, but in four of eight cases remissions have been seen, and three of the children are alive and free from symptoms after substantial periods—three years in one case. Because of the occasional occurrence of the spontaneous arrest already referred to, these results must be accepted with some caution; but if they fulfil their promise they offer hope of cure of a rare but deadly tumour. Suggesting as they do also a completely new line of tumour chemotherapy, their theoretical interest is perhaps even greater than their practical value.

The demonstration of a significantly high frequency of group *A* blood among patients with cancer of the stomach by workers at the Postgraduate Medical School, London, has been put on a firmer basis by the inclusion of statistics from several other centres, data on some thousands of cases being now available. It has been found that peptic ulcer presents an opposite effect: among patients with that diagnosis, group *A* is significantly less common, and group *O* more common than in the general population. It is cogently suggested that both these effects may be related to the high content of polysaccharides specific for blood groups in the gastric mucins. No other tumours of those investigated (Sheffield workers contribute a negative study of carcinoma of the breast on these lines) has shown any comparable effect.

The subject of the diagnosis of cervical carcinoma by cytological examination of the vaginal fluid has become the field of much partisan argument. It has become necessary to determine, not so much whether the method is of value, as whether the very large expenditure of skilled man-hours which it calls for is justified by the results in any given circumstances. Two correlated attempts at evaluation, sponsored by the Royal College of Obstetricians and Gynæcologists,

are here reported from Birmingham and Newcastle. Though both are in their early stages, they have provided some useful data and provoked some valuable comments. The experiment in Birmingham of leaving not only the work but also the whole responsibility of cytological diagnosis in the hands of a specially trained technician will be watched with special interest.

There is a brief account of a visit paid by Prof. J. W. Orr to Makerere College in Uganda and of the tumour material he saw there. The observations he was able to make in the time at his disposal on Kaposi sarcoma and primary carcinoma of the liver were not spectacular; but the pattern of visitation is one which should be more widely followed, and which the British Empire Cancer Campaign is in a uniquely favourable position to foster.

SEVENTEENTH-CENTURY CHEMISTRY, THE PHLOGISTON THEORY AND DALTON'S ATOMIC THEORY*

By Prof. J. R. PARTINGTON, M.B.E.

SOME important aspects of seventeenth-century chemistry are exemplified by the work of Van Helmont (1579–1644), Boyle (1627–91) and Mayow (1641–79). Van Helmont, a physician, held views on education in advance of his time, thinking that young men in universities should learn mathematics and the sciences, including chemistry with practical work. He criticized the theory of the four elements and also the alchemical three elements, salt, sulphur and mercury, believing that air and water are the true elements; fire never forms part of a material body and earth can be formed from water, as he tried to prove by experiment. He made chemical experiments using the balance, and showed that a metal dissolved in an acid or converted into a compound is not destroyed but can be recovered again with the same weight and properties as before. The products of distillation do not exist as such in bodies, but are formed by the action of heat. Van Helmont coined the name 'gas' and recognized the existence of different gases, such as carbon dioxide ("gas sylvestre"), nitric oxide and sulphur dioxide. He thought that a gas cannot be retained in a vessel, since a sealed vessel containing materials generating gas is burst. Although a gas as such is not retainable by bodies, some bodies contain gas in a fixed form, and it can be separated from them by heat, fermentation or acids. Van Helmont represents the transition from alchemy to chemistry, and used the quantitative method.

Boyle was well acquainted with the writings of Van Helmont, whom he greatly respected. Like him, he retained some old ideas on superstitious remedies, comparing their action with that of a magnet on iron. In his "Sceptical Chymist" (1661) Boyle repeated and extended Van Helmont's criticism of the four elements and three principles, and confirmed many of his experiments. Both believed in the possibility of the transmutation of metals. Boyle was the first (1660) to collect gases (hydrogen and nitric oxide); he investigated the effect of pressure on air, discovering Boyle's law, and made many experiments in the vacuum of an air-pump. His experiments on combustion and respiration were made in dry vessels; he found little or no change of pressure or "elasticity" of air, taking this to be its most distinctive property.

Boyle attempted to rid chemistry of mysticism by using the ideas of rational mechanics in explaining chemical phenomena, and by the use of the atomic (or "corpuscular") hypothesis, which he took from Gassend, and of the ideas of Descartes, he interpreted physical and chemical changes in terms of the shapes and motions of the particles of bodies; acids have pointed particles, and air particles behave towards pressure like coiled springs.

In experiments on combustion Boyle found that gunpowder will burn under water or (with difficulty) in a vacuum, and hence he suspected that air contains some vital substance which may be a volatile nitre and which supports combustion and respiration. He thought nitre crystals might contain admixed air, although he admitted that, on heating, nitre may evolve vapours which "emulate air". Since combustion and respiration cause very little change of pressure of air in dry vessels, Boyle thought there was very little of this "fine subject" in the air.

In his experiments on the calcination of metals in air in sealed retorts (1673), Boyle was misled by his method of working, since he opened the retort before weighing (when air enters to take the place of that absorbed by the metal), and he concluded that the increase in weight is due to the fixation of ponderable fire particles in the metal. From his experiments on respiration (1672), he concluded that the burning of flames and the breathing of animals might remove the same substance from the air, but he gave other alternatives: they might remove different substances, since a flame is extinguished while an animal is still alive. His conclusions were (as usual with him) presented with great caution.

More definite conclusions were drawn from such experiments by Hooke and Mayow. Hooke ("Micrographia", 1665) suggested, without any new experiments, that air and nitre contain a common constituent, nitre more plentifully, and that a burning body dissolves in air, producing heat, as when metals dissolve in acids. It was not until 1682 that Hooke called the common constituent of air and nitre "nitrous air" (a name used by John French in 1651), and proposed a theory of combustion similar to that given by Mayow in 1674. Hooke, who otherwise claimed discoveries published by others which he thought belonged to him, did not feel that Mayow had taken anything from him, and the two were friends. It seems, in fact, that the theories of Hooke and Mayow were different, Hooke regarding combustion as a passive solution of a body in air, and Mayow as a violent collision and interaction of combustible particles and particles in the air which he called "igneo-aerial particles", "nitro-aerial particles" or "nitro-aerial spirit" (a name used by Scaliger in 1557). These particles, Mayow suggested, are contained in the nitric acid part of nitre, which derived them from the air.

Mayow was a highly ingenious experimenter, devising new apparatus for manipulating gases and in studying combustion and respiration, which he investigated in the presence of water and hence found a decrease in volume or pressure, not noticed by Boyle. He supposed that air contains two kinds of particles, one (the nitro-aerial particles) removed in combustion and respiration, and he explained the change of volume or pressure by an ingenious theory

* Substance of a course of three lectures delivered in the University of London on May 5, 7 and 10.

based on the views of Descartes and Boyle of the corpuscular structure of air. He explained the increase in weight of antimony on calcination as due to the fixation in the metal of nitro-aerial particles from the atmosphere. In respiration, he assumed, these particles enter the blood from air in the lungs, and animal heat is due to their interaction with combustible particles in the blood, this taking place in part in the muscles and being the cause of muscular motion. In these three processes, the nitro-aerial spirit plays the part of oxygen. Mayow's explanations were often artificial, since they were conceived in terms of the prevailing views of Descartes, which were also used by Boyle. Newton's "Principia" was not published until thirteen years after Mayow's "Tractatus quinque" (Oxford, 1674). Newton's chemical ideas in his "Optiks" (1717) are similar to Mayow's. Mayow's views on chemical affinity are very correct and anticipated those of Geoffroy (1718) and Berthollet (1801). The very severe criticism of Mayow by T. S. Patterson (1931) was exaggerated and incorrect in detail. Mayow's dependence on Descartes was overlooked, the originality of his experiments was not appreciated, and Mayow's supposed dependence on Boyle, Hooke, Lower and Thruston was based on ignorance of earlier work. The correct parts of Patterson's criticisms had been, unknown to him, anticipated by Jonathan Stokes in 1800. Indeed, a new study of Mayow, having due regard to the facts, is needed.

The phlogiston theory is a complicated and difficult subject. The name "phlogiston" for a supposed material constituent of combustibles was used by Hapelius (1606), Van Helmont, Sennert and Boyle before Stahl, starting from some ideas of Becher (1669), proposed (first in 1697) what is called the old phlogiston theory. This was soon accepted and, combined with the replacement of Descartes's ideas by those of Newton, caused neglect of the more correct views of Boyle, Hooke and Mayow. The theory assumed that phlogiston is the material of fire, not fire itself; it is a dry earthy substance, soot being nearly pure phlogiston, although phlogiston was also supposed to escape in invisible particles from a burning body. It exists in animal, vegetable and mineral bodies, is the same in all, and can be transferred from one body to another. A metal is a compound of its ash (or "calx") and phlogiston; on heating in air the metal loses phlogiston, and on heating the calx with a body rich in phlogiston the metal is formed again. Sulphur is a compound of sulphuric acid and phlogiston; and all acids are modifications of sulphuric acid, the universal acid. Phlogiston is the cause of odour and colour.

Stahl's theory inverted the true theory of combustion and calcination and neglected quantitative aspects; although Stahl knew that the calx weighed more than the metal, he did not explain this, beyond saying that phlogiston is a weightless matter which when it enters bodies makes them lighter. The theory combined many isolated facts into a comprehensive body of false doctrine, made them easier to remember, and was very popular until towards the end of the eighteenth century.

As new facts accumulated the phlogiston theory underwent many modifications, including the views that phlogiston is hydrogen (Cavendish, 1766) or the matter of light (Macquer, 1749). The theory suggested new experiments: Scheele's discovery of oxygen 1772) was based on it, and Cavendish explained the synthesis of water (1784) in terms of it. Attempts to explain the increase in weight on calcination of a metal included the assumptions that phlogiston was lighter than air, or even that it had an absolute negative weight.

Lavoisier's theory of combustion was that oxygen gas is a compound of a base and the matter of heat or "caloric", an imponderable fluid which in some respects played the part of phlogiston. A burning body combines with the oxygen base and sets free the caloric as heat and light. This theory was seen to be unsatisfactory, since heat and light are evolved in the combination of solids as well as gases, and several modifications of it were proposed. In one, the combustible was assumed to be a compound of a base and phlogiston, and oxygen gas a compound of a base and caloric. The two bases combine to form an oxide, and the phlogiston and caloric combine to form light. It was only after the introduction of the theory of energy, about 1850, that a chemical explanation of the formation of heat and light in combustion was felt to be unnecessary, and the process was interpreted in a manner reminiscent of Mayow's theory—namely, as due to the collision of particles of the combustible and of oxygen.

Dalton's atomic theory was the first to make successful use of the old Greek theory of atoms in chemistry. The old theory had been used quite extensively in the seventeenth and eighteenth centuries by Gassend, Sennert, Magnenus, Boyle, Mayow and Newton. Newton's treatment of the physical nature of air, as consisting of particles repelling each other with a force inversely proportional to the distance (which gave Boyle's law), needed modification when air was recognized (as Mayow had seen) as containing two kinds of particles, and when different gases were discovered late in the eighteenth century and it was shown that two gases (ammonia and hydrochloric acid) combine to form a solid. Bryan Higgins (1776) supposed that gaseous particles are surrounded by mutually repelling atmospheres of caloric, and explained the formation of compounds $A+B$ of the atoms of two different gases. William Higgins, in his "A Comparative View of the Phlogistic and Antiphlogistic Theories" (1789), explained the formation of compounds of one atom of A with one, two, three, four or five atoms of B in terms of a force of attraction which divided itself among the combining particles. Although the law of multiple proportions may be read into his speculations, if Higgins supposed that the atoms of different elements have different weights, he expressed it so obscurely that authorities cannot agree on the matter.

John Dalton (1766–1844), born in Cumberland of a Quaker family and almost self-taught, became a schoolmaster in Kendal, where he wrote his "Meteorological Observations and Essays" (1793), containing the germs of his later discoveries. In 1793 he moved to New College, Manchester, as tutor, resigning in 1799, and thereafter supported himself by private tuition and consulting work. In his book, Dalton had proposed the new view that water vapour in the atmosphere is not chemically combined but mixed with the other gases. In developing this idea in 1801, he discovered his law of partial pressures, which he expressed in terms of Newton's theory by saying that particles of any one gas in a mixture repel one another but not the particles of other gases. He regarded the gaseous particles as surrounded by repelling atmospheres of caloric, and to explain gaseous diffusion he supposed that the atmospheres differed in size in different gases. From this view, in the autumn of

1803, he came upon the idea that atoms of different elements have different weights, and he probably presented the first table of atomic weights in a lecture in 1803 to the Manchester Literary and Philosophical Society, which was published in 1805. All the details of Dalton's chemical atomic theory are given, explicitly or implicitly, in an entry in his note-book on September 6, 1803 (his birthday), and he held these unchanged until the end of his life. Dalton calculated the atomic weights from the quantitative compositions of compounds and assumptions about the numbers of atoms of the elements in a particle of a compound. The numbers were not accurate, but they were based on analyses by well-known contemporary chemists, not by Dalton. He later said that he would publish only what he had confirmed, since he had often been misled, a statement which has erroneously been said to imply conceit on his part; there are, in fact, many assertions about Dalton based largely on ignorance.

The first printed statement of Dalton's atomic theory is that in the "System of Chemistry" (1807) of Thomas Thomson, who visited Dalton in 1804 and found him analysing marsh gas and ethylene, and Thomson afterwards said that Dalton's atomic theory was evolved to explain the results, which indicated a law of multiple proportions. The theory had, in fact, been arrived at in 1803. In 1808 Dalton gave a brief account of the theory in his "New System of Chemical Philosophy", with a table of atomic weights and plates of chemical symbols. He also gave some "general rules" for arriving at the numbers of the atoms of the elements A and B in a "compound atom" of a compound. If only one compound is known, it is $A+B$; if there are two compounds they are $A+B$ and $2A+B$ or $A+2B$, etc. Dalton had concluded from the combining volumes that equal volumes of gases cannot contain the same number of atoms (which is correct); but he did not consider the possibility that the particles of elementary gases may contain two or more atoms, and Avogadro's hypothesis (1811) was not used by chemists until Cannizzaro (1858) directed attention to it—it enables the numbers of atoms in a molecule of a compound to be found, and hence the atomic weights may be determined without ambiguity.

Dalton's atomic theory, it will be seen, differed in important respects from the modern theory, but it laid an enduring foundation for future progress. In addition to it, Dalton made important discoveries in chemistry and physics both before and after announcing his atomic theory. His work on the uniform expansion of gases by heat, on vapour pressures, on the law of partial pressures, and on gaseous diffusion was done in an early period (1800–04); later, important work was on the incomplete combustion of hydrocarbons (1805), on the volumes of solutions, and on the composition of the atmosphere at high altitudes, which he found nearly the same as at sea-level, explaining the result as due to convection (a theory proposed again in recent times). He was a skilful and accurate gas analyst.

Dalton became internationally famous after his publications in 1801. He was a *correspondant* member of the Paris Academy of Sciences in 1816 and one of the eight foreign associates in 1830, a Fellow of the Royal Society in 1826, a D.C.L. of Oxford in 1832 and in the same year an LL.D. of Edinburgh. In 1833 he began to receive a Civil List pension. He died suddenly in his room in 1844 and was buried in Manchester with civic honours. Dalton was greatly liked and respected by his contemporaries, his two main characteristics being his constant truthfulness and his great originality, both of which are quite incompatible with the assertion of Higgins in 1814 that Dalton arrived at his atomic theory by reading Higgins's book of 1789. There is no evidence that Dalton owed anything to his predecessors except Newton; this charge originated with Higgins alone, and if it has afterwards been repeated, it has always been withdrawn.

OBITUARIES

Prof. F. E. Fritsch, F.R.S.

F. E. Fritsch, emeritus professor of botany in the University of London, died on May 23 at the age of seventy-five. Of German descent, but born in London, he became truly English, though in his remarkable thoroughness and the solidity of his literary work he betrayed mental features held to be characteristic of German scholars. Asked how he managed to make fewer mistakes in his quotations and references than almost anybody else, he answered: "I am very slow though". This reply indicates how much time and trouble he devoted to every task he undertook.

Prof. Fritsch was head of the Department of Botany in Queen Mary College (University of London) during 1911–48. He began his academic career as assistant in the Botanical Department of the University of Munich during 1899–1901, then lectured in University, Birkbeck and East London (Queen Mary) Colleges of the University of London before taking the chair at Queen Mary College. He was president of Section K (Botany) of the British Association in 1927, president of the Linnean Society during 1949–52 and chairman of the Council of the Freshwater Biological Association of the British Empire.

Fritsch's inclination and gifts were more like those of a philologist commenting on ancient texts, and drawing careful conclusions from them, than those of a biologist who puts, by experimental means, his questions to Nature itself. But in his own investigations he was as painstaking and accurate as possible.

Since he came to be interested in morphology, the immense variation in the shaping of the Algae became, in his later years, his main attraction. There was scarcely ever a person who knew so much about them, and his life's work, "The Structure and Reproduction of the Algae", could not have been written by anybody else with the same degree of comprehension and authority.

Frail in body but strong in mind, Fritsch was a personality not to be overlooked in any assembly, and it is not surprising that he was often made a chairman by his colleagues. People used to look up to him, although he was small in stature.

Fritsch was asked for advice by numerous people who knew of his reputation as a most reliable man, and he did not spare himself, but he always kept his superiority. So long as this remained untouched, he could be the friendliest, most considerate and helpful man. He was a great talker, critical but benevolent, and resourceful in council.

Since his teaching, literary work and many dignities, combined with travelling—sleeping away from home and working in the train—eventually took most of his time and energy, gardening and music which had been his favourite spare-time occupations

were gradually given up, but he did not rest much until near the end of his long life.

Fritsch's publications will remain standard works for some time to come. He himself will be missed by many as a strong supporter of order, prudence and loyalty.

E. G. Pringsheim

The botanical world, and more especially the phycological section of it, has suffered grievous loss in the passing of Prof. Fritsch. Few men have attained the degree of eminence to which, despite physical frailty, his intellectual power, human wisdom and qualities of leadership raised him.

His primary interest was in the freshwater algae, in the study of which he made notable contributions to knowledge; but his interests were wide, and in the related field of marine phycology, his encyclopædic knowledge and sound judgment made him one to whom research workers in Great Britain and overseas turned inevitably for opinion and guidance. Help was always given freely and generously. He had that faculty of detached consideration of other people's problems that is not only invaluable but is also heart-warming and stimulating.

Prof. Fritsch's work, whether designed for the needs of elementary students or research workers, was always characterized by meticulous accuracy and a wealth of detailed information. The two volumes, "The Structure and Reproduction of the Algae", must remain as classic for all time; the completeness of the bibliography would alone ensure their permanent value, and that, coupled with the breadth and precision of the text, establishes the volumes as a *vade mecum* for all phycologists.

Though valuable scientific contributions, remarkable both in quantity and quality, earned for Prof. Fritsch both respect and admiration, his delightful human qualities also drew forth affection. It was a privilege to be associated with him for more than thirty-five years, and to have received from him an early training in university examining, in which his breadth of scholarship, fair-mindedness—especially to those less gifted than himself in graceful expression—provided an example to be remembered and followed.

Prof. Fritsch found great relaxation in music, and many of his friends will cherish memories of delightful week-ends at his home in Surrey where he and Mrs. Fritsch dispensed gracious hospitality. At the outbreak of the Second World War, Prof. Fritsch moved to Cambridge, where his home became again a social centre and focal point for botanists, from Great Britain and overseas. He faced the problems of war, as indeed he faced all other difficulties, with calmness, merely taking every possible precaution to safeguard scientific material and then going on quietly with his work, adding still further to scientific knowledge. It is regrettable that he himself will not see the publication of his current work on the calcareous algae.

Those who were privileged to be admitted to the friendship of Prof. Fritsch will be glad to express personal gratitude for unstinted and generous encouragement and to join with vast numbers of those who knew him in extending their sympathy to Mrs. Fritsch and her son. She must surely find some measure of comfort and pride in the knowledge of the sincere esteem and affection in which her husband was held by scientists all over the world.

Margery Knight
Lily Newton

Dr. Malcolm Burr

Dr. Malcolm Burr, whose death at the age of seventy-six, due to an accident, occurred on July 13 in Istanbul, was a most colourful figure. A mining engineer by training, he took part in the development of the Kent coalfield at the beginning of this century, prospected for coal in Angola and visited the Lena goldfields and manganese mines in the Caucasus between the two World Wars, not to mention many other professional tasks. His main scientific interest in life, however, was entomology, and even as a schoolboy he specialized in Orthoptera and Dermaptera. When only twenty years old, he visited Vienna and, under the stimulus of Dr. Brunner von Wattenwyl, produced a revision of the genus *Acrida*. A long series of articles on the systematics of other Orthoptera followed, as well as a monograph of the family Eumasticidae, the first of this group. His principal contribution was to the study of the Dermaptera, which he was the first to classify on the basis of the structure of the copulatory organs, and on which he published a classical revision in Wytsman's "Genera Insectorum", as well as a volume in the "Fauna of British India", apart from very numerous journal papers. Dr. Burr's valuable collection of world Dermaptera, containing many type-specimens, has been presented by him to the British Museum and his rich collection of European Orthoptera, including many collected by himself, to the Hope Museum, University of Oxford.

Financial misfortunes and a restless character made it impossible for Burr to settle down, and in his old age he became a journalist, author of delightful travel and natural history books and finally professor of English at Istanbul. One of his most remarkable abilities was the gift of learning languages—he spoke fluently all the European ones, including several Slavonic. His last letter to me, dated July 2, 1954, full of entomological inquiries, was written in a vivid, if not strictly grammatical, Russian, a language which he never attempted to learn, but merely 'picked up' during his visits to Russia more than thirty years ago and never forgot.

The Royal Entomological Society of London has lost in Dr. Burr one of its oldest Fellows, elected in 1896. Apart from his many publications, he rendered an important service to entomology by having been one of the active group which founded the International Entomological Congresses and the honorary secretary of their permanent executive committee until 1920.

B. P. Uvarov

Dr. R. W. Pocock

Dr. Roy Woodhouse Pocock, formerly a district geologist of the Geological Survey of Great Britain and a member of its staff for thirty-six years, died suddenly on June 22, while on holiday in Brussels.

Pocock was born in 1887 and, after leaving school, he became an assistant in the Geological Department of the British Museum (Natural History), in the meanwhile working for an honours B.Sc. degree at evening classes at Birkbeck College, London. During this time he began an investigation of the Silurian inlier of Woolhope, Herefordshire, and discovered there a thin limestone largely composed of the remains of the crinoid *Petalocrinus*, previously known only from the Niagara Limestone of North America and the Silurian beds of Gotland. He presented specimens from Woolhope to the British Museum

(Natural History) in 1911; but his work on the "*Petalocrinus* Limestone" was not published until 1930, in the *Quarterly Journal of the Geological Society of London*.

Pocock was appointed to the Geological Survey in 1912 and for about two years was assigned to work in Hertfordshire. During the First World War he was one of three members of the Geological Survey staff selected to go to the Eastern Mediterranean to advise on problems of water supply for the Army. On his return to England he received a commission in the Royal Garrison Artillery.

After the First World War, until his promotion to be district geologist in 1937, Pocock took part in the surveying of six one-inch sheets covering areas in Shropshire, Staffordshire and Worcestershire, and was principal or part author of the corresponding memoirs. His work in the western part of the Coalbrookdale Coalfield led to his contributing to the "Summary of Progress of the Geological Survey" for 1925 a paper on "The Basalt of Little Wenlock", in which he demonstrated the rock to be a lava of Lower Carboniferous age. Pocock extended his investigations to basalts among Upper Carboniferous sediments in the Midlands and, in a paper published in the *Quarterly Journal of the Geological Society* in 1931, concluded that all of them are of Carboniferous age and most of them of extrusive origin. The latter contention has not in all cases met with general acceptance. For his work on "The Age of the Midland Basalts", his *Petalocrinus* paper and other writings on the geology of the Welsh Borderland, Pocock was in 1932 granted the D.Sc. degree of the University of London (not an 'honorary' degree as has been stated elsewhere). His official work in Shropshire resulted also in his collaborating with E. S. Cobbold in a paper on "The Cambrian Area of Rushton, Shropshire", published in the *Philosophical Transactions of the Royal Society* in 1934.

On his promotion to be district geologist, Pocock took charge of the Bristol and South Wales District, and himself carried out mapping of rocks of Silurian and Old Red Sandstone age in the Chepstow Sheet. He retired from the Geological Survey in 1948.

Pocock was awarded the Lyell Fund of the Geological Society in 1932. He served on that Society's Council during 1937–42 and was a vice-president in 1941 and 1942. He was treasurer of the Geologists' Association during 1950–52.

T. H. WHITEHEAD

NEWS and VIEWS

Mathematics at the Imperial College of Science and Technology: Prof. H. Levy

PROF. H. LEVY joined the staff of the Mathematics Department of the Imperial College of Science and Technology, London, in 1920 from the Aerodynamics Division of the National Physical Laboratory. He was appointed professor in 1923, succeeded Prof. S. Chapman as head of the Department in 1946, and was also dean of the Royal College of Science from 1946 until 1952; he is due to retire this year after thirty-four years continuous service in South Kensington. In that time he has achieved much distinction; academically he has been the inspiration of a gradual and forceful revolution in the content and quality of the mathematics instruction and research at the College. He has never allowed himself to rest contented with his achievements, and continues still to work to keep the Department abreast of the rapidly changing demands of present-day science and technology. In the College he has been well known to generations of students in all departments. With an unfailing sense of humour, and a human sympathy, he is one of the most approachable of men and is never too busy to talk with anyone who desires his help. He has preserved an independence of outlook and possesses a remarkable facility of spontaneous and sensible expression which, when he leaves, will be missed by his colleagues on many boards and committees. For the time being, however, they are fortunate in that Prof. Levy has agreed to delay his retirement for six months.

Geography at Edinburgh: Dr. J. W. Watson

DR. JAMES WREFORD WATSON, chief geographer of Canada, has been appointed to the chair of geography in the University of Edinburgh in succession to the late Prof. A. G. Ogilvie. Born of missionary parents in China in 1915, Dr. Watson spent his early years in the Far East, but went to Edinburgh at the age of twelve to be educated at George Watson's College and the University, where he graduated with first-class honours in geography in 1936. After two years as lecturer at the University of Sheffield, he was invited to introduce the teaching of geography to McMaster University, Ontario, first as lecturer and later as professor (1945–51). During this period he took his Ph.D. at Toronto and was for a time visiting professor at the University of Florida. In 1949—being 'lent' for a time from McMaster—he was appointed the first chief geographer of Canada and director of the Geographical Branch of the Federal Government. In this capacity he has initiated and organized a great variety of geographical surveys, many of them in the Canadian Arctic. He has also been responsible for compiling and editing the new "National Atlas of Canada", to be published in 1955. Besides extensive travel in North America, he has a first-hand knowledge of many parts of South America, Greenland and several European countries. Although so much of his working life has been spent in administration and travel, and in the supervision of the researches of others, Dr. Watson has found time for a good deal of personal research, recorded in twenty-five papers, some of which are substantial studies in sociological, economic and historical geography, marked throughout by originality of approach and method and by clarity of expression and illustration. Early this year he received an Award of Merit from the Association of American Geographers for his "distinguished services in the establishment of a geographical office in the Canadian Government and for original contributions to the historical geography of settlement".

Chemicals in Food

AT the eighth annual general meeting of the British Food Manufacturing Industries Research Association, held on June 3, Sir Frank Engledow, in his presidential address, surveyed the problem of chemicals in food against the background of the fourth annual report

of the Advisory Council on Scientific Policy, 1950–51 (Cmd. 8299; H.M.S.O.). This report states "that the risk to life and health due to the presence of toxic substances in consumer goods is probably small, but the rapid growth of chemical industry, and the needs of the food-processing industries for substances to replace scarce materials or for chemical substances which have a claim to use on their own merits as improvers of appearance, palatability or texture of manufactured foods, are accelerating the pace at which new chemical substances are being introduced into consumer products, and the machinery which exists for testing the possible harmful effects of these substances is inadequate". Sir Frank suggested that the food industries should searchingly examine their own attitude with the view of the formulation of a policy "constructively, not merely defensively". It is completely indefensible, he said, to attempt to offset the seriousness of the problem by comparisons with other hazards to health, such as those arising from atmospheric pollution and other causes; but the time is opportune for the preparation by industry of a reasoned case demonstrating the necessity of various methods of food preservation for different purposes, to make full use of seasonal crops, to allow for necessary delays in manufacturing processes and to ensure the distribution of world or national food supplies over wide areas. Such a statement might constitute a valuable contribution to public understanding and would help the industries to make sure that they are fully meeting their responsibilities by thoroughly probing all the complex issues. It is essential, Sir Frank continued, that all food firms should make full use of the whole of existing knowledge and take a scientific attitude to it; the British Food Manufacturing Industries Research Association can play a very important part and warrants the support of all firms in the industries concerned.

Legal Protection of Laboratory Animals Overseas

Some time ago, two scientists working in another country asked the Universities Federation for Animal Welfare (Great Britain) to suggest a form of legislation for the protection of laboratory animals which they might urge their own Government to adopt. In order to clarify the legal requirements, the Federation has drafted a summary of the Cruelty to Animals Act, 1876, and of the practices which have gradually come to be based upon it.

In Britain, the preparation of biological therapeutic substances for medical and veterinary use is controlled by statutes other than the 1876 Act; the animals involved are subject to inspection, and the Universities Federation for Animal Welfare considers this legal control and inspection important. The relevant British statutes are the Therapeutic Substances Act, 1925, and subsequent rules and orders, administered by the Ministry of Health, and the Diseases of Animals Act, 1950, and Diseases of Animals (Therapeutic Substances) Order, 1952, administered by the Ministry of Agriculture. The protection of all other laboratory animals is in the hands of the Home Office, which is equivalent to the Ministry of the Interior in most countries. The Federation considers that this is a good arrangement, since the Home Office is in a position to give an unbiased opinion when the claims of science have to be weighed against the welfare of laboratory animals. The Federation also considers that special breeding of all laboratory animals is desirable. In Britain many institutions breed their own animals, and a list of accredited breeders has been compiled by the Laboratory Animals Bureau, Medical Research Council, Holly Hill, Hampstead, London, N.W.3.

Ten-Tola Primary Standard Weight for Karachi Mint, Pakistan

L. Oertling, Ltd., have completed the manufacture for the Karachi Mint, Pakistan, of what is believed to be the first primary standard weight manufactured commercially in Britain since before the War. The weight is of iridium–platinum alloy and is a cylinder having a diameter equal to its height with a mass of 10 tolas (1,800 grains or about 117 gm.). The billet from which the weight was manufactured was forged by Johnson Matthey and Co., Ltd., Hatton Garden, London, E.C.1, and the production of such a billet to very close specific gravity limits reflects great credit upon their skill. The certification of the specific gravity and the accuracy of adjustment was carried out by the National Physical Laboratory, Teddington. A special pair of forceps, container and carrying case are provided. The manufacture and adjustment of a weight in the form of a solid cylinder to an accuracy of two parts in one million represents a skill of a very high order. Since it is impossible to make any adjustment to the weight should it become too light, the weighing and counter-weighing of the mass becomes extremely critical as the limits of adjustment are approached; this work was carried out in the Weight Department of Messrs. Oertling.

The British Civil Service, 1854–1954

At the suggestion of the Civil Service National Whitley Council, Mr. Wyn Griffith has written an excellent concise account of "The British Civil Service, 1854–1954" (pp. 32+4 plates. London: H.M.S.O., 1954; 1*s.* net) which has been published "at the direction of H.M. Treasury" on the occasion of the centenary of the publication of the Northcote-Trevelyan Report. In the broad perspective of this commemorative booklet, though the change in character and responsibilities of the Service are noted, the treatment of these aspects of special interest to the professional man, and particularly the scientific worker or technologist, is slight; nevertheless, the growth of the Scientific Civil Service is described as the outstanding development of recent years. Read with intelligence and reflexion, the booklet gives a clear enough guide to the real problems of the Civil Service to-day and the factors which determine its strength and weakness (see also p. 281 of this issue).

New Technical Bulletins on Rubber Research

The first of a series of technical bulletins to give information on new materials and processes resulting from the research and development work of the British Rubber Producers Research Association has just been issued by the British Rubber Development Board (Market Buildings, Mark Lane, London, E.C.3). The object of the bulletins is to provide factual information, particularly for the industrial technologist, on subjects which have reached a stage of more practical interest. They will therefore supplement to some extent publication of the Association's work in technical and scientific journals. "B.R.P.R.A. Technical Bulletin No. 1: Heveaplus M" is a well-produced, illustrated booklet (pp. 20; 1954) which describes various products obtained by treatment of hevea rubber latex with methyl methacrylate. These products are of much interest since they represent successful attempts to improve natural rubber and to

confer on it some of the various advantages which have been claimed for speciality synthetic rubbers. 'Heveaplus MG' is a graft polymer obtained by polymerizing methyl methacrylate in rubber latex, while 'Heveaplus MM' is prepared by mixing a dispersion of polymethyl methacrylate with concentrated ammonia-preserved rubber latex followed by coagulating, washing and drying. In both types, a final number indicates the percentage of (poly) methyl methacrylate present in the product. Details of the chemical and physical properties, processing, vulcanization, reinforcing power, etc., of these interesting new materials are also given.

Properties of Materials at Low Temperatures

ANNEXE 1954–2 of the Bulletin of the International Institute of Refrigeration (177 Boulevard Malesherbes, Paris 17e) records the proceedings of the meetings of Commissions 1 and 2 of the Institute held at Zurich in September 1953; the publication has just become available. Nineteen papers were presented and some of the topics discussed are indicated below. A paper by Long and Simon describes a helium liquefier constructed with an elastic metallic bellows in place of the conventional cylinder and piston. Van Itterbeek describes an adaptation of the Collins liquid helium cryostat to a closed cycle so that the same quantity of helium gas is circulating and the loss reduced to a minimum. An apparatus which permits of the liquefaction of hydrogen and helium in the same unit is described by Spoendlin, and Myncke describes a liquid-air plant with propane precooling circuit. Wucherer reviews the development of expansion turbines for low temperatures and quotes figures for the high efficiency attainable. Heat-transfer calculations for a cross-flow regenerator are given by Hausen. Four papers deal with the low-temperature properties of metals: the mechanical properties of ferritic steels at −196° C., by Allen; the effects of low temperatures on some engineering properties of metals, by Oliver; the thermal conductivities of metals below room temperatures, by Powell; and strength of aluminium crystals at low temperatures, by Eder. Two papers deal with thermal insulation problems: one on the thermal conductivity of porous materials containing air under reduced pressure, by Paemel; and a note on the thermal conductivity of moist cork, by Hatton and Zaki. A survey of the field of work of Commission 2, which has for its terms of reference the study of heat transfer, insulating materials, instrumentation, and thermal properties of materials, was given by Griffiths. The next joint meetings of Commissions 1 and 2 will take place at Grenoble on September 24 and 25 of this year.

Constants of the Stellar Velocity Ellipsoid

WHEREAS previous derivations of the constants of the velocity ellipsoid of stars have been based on the radial velocities of the brighter stars, in a paper by D. G. Ewart (*Mon. Not. Roy. Astro. Soc.*, **113**, 5; 1953) the derivation is based on the radial velocities of 820 stars the *HD* photographic magnitudes of which range from 8·5 to 8·6 and the spectral types of which are *F*–*M*. The calculations were simplified by using large regions of the sky, which was divided into thirty-four areas, according to galactic latitude, and antipodal areas were combined to give seventeen regions over one hemisphere. The final results for the solar motion were: $U = 20{\cdot}36$ km./sec.; $A = 275° 07'$; $D = +40° 44'$; $G = 35° 53'$; $g = +21° 18'$, with a K term of $-0{\cdot}22$ km./sec. The mean results previously obtained by Moore and Paddock were: $U = 22{\cdot}44$ km./sec.; $A = 280°$; $D = +44° 30'$, from which it appears that the high value of the declination of the solar apex obtained by Moore and Paddock is partly confirmed by Ewart's work. It is suggested, however, that as the stars used in earlier work on radial velocities were generally brighter than the sixth apparent magnitude—very much brighter than those used in the present investigation—there may be a magnitude variation in the solar motion.

The same division of the sky was used for the determination of the constants of the velocity ellipsoid, and a table shows the values obtained for $1/K$, $1/H$, K/H and G_0 for the different zones; but it is pointed out that the only result to which any significance can be attached is that for all stars. In this case the values are 37·24, 25·80, 0·693 and $321° 44' \pm 3° 31'$, respectively, one main feature of which is that the ratio $K/H = 0{\cdot}693$ is well defined and agrees closely with proper-motion results. Delhaye's figures, published in 1952, obtained by analysing the proper motions of faint stars in the Boss General Catalogue, indicated that the phenomenon of the deviation of the vertex is confined to the nearest stars and is not exhibited by the fainter and more distant stars, and it is significant that in Ewart's investigation the deviation of the vertex is barely evident. It is suggested that there should be further examination for a possible variation of the declination of the solar apex with apparent magnitude, and also for the dependence of the deviation of the vertex on the distances of the stars used in its determination.

Radioactive Tobacco Mosaic Virus

F. L. WYND has reported on the preparation of radioactive tobacco mosaic virus (*Lloydia*, **16**, No. 4, 233; 1953) by growing young tobacco plants in hydroponic culture low in phosphate for three weeks. Radioactive phosphorus in the form of orthophosphoric acid was then added to the nutrient solutions and seven days later each plant was inoculated with the disease by rubbing the lower leaf with liquid obtained from macerated diseased leaves. Sixty-two days after inoculation, the plants were harvested and the virus recovered by differential ultracentrifugation. A purified virus suspension was obtained exhibiting a radioactivity of 2·54 μc./mgm. of virus phosphorus. This activity was significantly greater than those reported by previous investigators. The probable purity of the recovered virus was evidenced by electron photographs. The high radioactivity of the purified virus should permit its use in further studies of certain aspects of the physiology and biochemistry of this virus disease.

The Council for the Preservation of Rural England

THE twenty-eighth annual report of the Council for the Preservation of Rural England quotes an example from Sheffield to illustrate the need for constant vigilance in seeing that land scheduled as 'green belt' in local authorities' development plans is not used for other purposes. The Sheffield and Peak District Branch of the Council is very concerned about possible encroachments on the Sheffield 'green belt' as envisaged in the City's Development Plan. At a public inquiry in July 1953 the Branch lodged certain objections and received an assurance that various farm lands left uncoloured on the map and designated

as agricultural areas would not be interfered with and would continue, as shown in the development plan, in their existing use. Before the decision of the Minister of Town and Country Planning could be promulgated, and within less than seven months from the inquiry, the Branch reports that Sheffield City Council has adopted a resolution to change certain provisions in it and to allocate portions of this land for building, without formal amendment or a public hearing. It would appear, therefore, that 'unallocated' land in a development plan can be developed at any time. If this is not the case an official assurance to the contrary would be welcomed.

Numbers of Man and Animals

The Institute of Biology is organizing a symposium under the general title "The Numbers of Man and Animals", to be held at the Royal Geographical Society, London, during September 24–25. The symposium is to be opened by Sir Alexander Carr-Saunders, and the first session will be concerned with the varied approaches of the economist, demographer and anthropologist, papers being given by A. T. Peacock, E. Grebenik and Prof. I. Schapera. The second session (chairman, Prof. C. H. Waddington) will begin with a study of the mathematical approach to population dynamics by Mr. J. G. Skellam. Dr. D. S. Lack, D. H. Chitty and Prof. T. Park (Chicago) will then deal with various aspects of the study of animal populations. The third session (chairman, Prof. J. Z. Young) will be concerned with the effects of disease, fertility and nutrition on the structure of populations. Papers are to be given by Dr. A. S. Parkes, Prof. A. L. Banks and Dr. J. Hammond. In the final session (chairman, Prof. S. Zuckerman) Dr. Fraser-Darling is to speak from the point of view of the ecologist, Prof. L. S. Penrose will discuss changes in the quality of human populations and Lord Boyd-Orr will comment on the future outlook. Copies of the various papers will be available some weeks before the meeting. Further information can be obtained from the General Secretary, Institute of Biology, Tavistock House South, Tavistock Square, London, W.C.1.

Ninth Electronics Course at Harwell

Applications are invited by the Atomic Energy Research Establishment, Harwell, from physicists and electronic engineers holding a degree or equivalent qualification, who wish to attend the ninth electronics course. The course covers the design, use and maintenance of electronic instruments used in nuclear physics, radiochemistry, and in work with radio-isotopes. It is to be held at the Isotope School, Harwell, during November 1–5. Attendance at the course is limited to 12 students. The syllabus will include lectures and practical work concerned with counters, D.C. and pulse amplifiers, coincidence units, scalers and ratemeters, and the lecturers and demonstrators will be specialists from the Atomic Energy Research Establishment. The fee for the course is twelve guineas, and living accommodation can be arranged locally at a charge of five guineas approximately. Further information can be obtained from the Electronics Division, A.E.R.E., Harwell, Didcot, Berks. Application forms must be returned by October 15.

Announcements

The Royal Society of Arts has awarded the R. B. Bennett Empire Prize of 100 guineas for 1954 to Dr. C. J. Mackenzie, president of the Atomic Energy Control Board, Canada. The Prize was founded in 1945 by the late Viscount Bennett, a former president and chairman of council of the Royal Society of Arts, and is awarded every three years "for the most outstanding contribution from the Dominions, India, Burma and the Colonies, to the promotion of the arts, agriculture, industries and commerce of the overseas empire during each intervening period".

Dr. A. Fröhlich, lecturer in the University College of North Staffordshire, has been appointed to the University readership in pure mathematics tenable at King's College, University of London.

The annual conference of the Society of Leather Trades' Chemists will be held in the Large Chemistry Lecture Theatre, University of Leeds, during September 24–25. On the afternoon of the first day, the sixth Procter Memorial Lecture of the Society will be delivered by Prof. J. T. Randall, Wheatstone professor of physics, King's College, University of London, his subject being "Observations on the Collagen System". Further information can be obtained from the honorary secretary, G. H. W. Humphreys, Forestal Central Laboratories, Harpenden, Herts.

From August 18 until the end of the year, the Science Museum will be showing some of the most important books on astronomy which were published between the fifteenth and the middle of the nineteenth centuries. The exhibition will include copies of Newton's "Principia", Copernicus's "De Revolutionibus Orbis", as well as works of Tycho Brahe, Kepler, Halley and Herschel. The exhibition will include photographs of many of the illustrations in the books. The Royal Astronomical Society has lent a number of books from its library to supplement the Science Museum's own collection.

A course on the measurement of the particle-size characteristics of fine powders will be given by Dr. H. E. Rose in the Faculty of Engineering, King's College, University of London, during the week commencing September 27. The course is primarily intended for graduates engaged in industry and will consist of a series of lectures, tutorials and demonstrations in the more common techniques for the determination of the size-characteristics of powdered materials in the sub-sieve range. The fee is five guineas. Forms of application should be returned not later than September 10, and further information can be obtained from the Dean of the Faculty of Engineering, King's College, London, W.C.2.

The X-ray Analysis Group of the Institute of Physics will be holding its autumn conference during October 22–23 at the Royal Institution, Albemarle Street, London, W.1. The subjects to be dealt with at the conference will be the structure and texture of metals. There will be an evening discourse on October 22 by Prof. A. H. Cottrell on dislocations. The conference is open to all, without charge, on completion of an application form, copies of which can be obtained from the Deputy Secretary, Institute of Physics, 47 Belgrave Square, London, S.W.1.

We regret that Sir Harold Hartley's signature was inadvertently omitted from the obituary notice of Dr. O. J. R. Howarth published in *Nature* of August 7, p. 249, although it appeared in the list of "Contents".

SCIENCE IN THE MODERN WORLD

IN a paper entitled "The Task before Us", read before the American Academy of Arts and Sciences at Boston on April 14*, Dr. P. W. Bridgman examined the philosophy of the founding fathers of American democracy in the light of the scientific thought of this century. He suggested that we have forgotten to regard democracy as a growing thing, evolving to meet our changing conceptions of ourselves and our place in Nature. Anti-intellectualism, he said, might be a symptom of something more deep-seated, and the emphasis on a return to humanistic attitudes requires a revitalization of the humanities themselves in the light of our recent intellectual experiences. We need to assimilate into our whole intellectual outlook, and in particular into our relation to social problems, the lessons implicit in scientific experience. Considering first the changes in intellectual attitude forced on us by such experience, Dr. Bridgman said that a necessary mark of a liberally educated man is the realization that our thinking and intellectual processes in general cannot be taken for granted. When we think, we use intellectual tools, and these tools have properties and limitations. In particular, recent experience shows that when we push the application of many of our concepts into new fields, limitations appear which we could not have anticipated from anything in our former more limited common-sense experience. We have now come to expect that a concept inherited from our ancestors will not be applicable when pushed into fields hitherto unentered. Analogy suggests that the presumption is that such concepts as human rights or duties or responsibilities require modification when the environment in which they arose is altered, as it now is, by technological advances that bring all men over the whole world into immediate mutal relations.

Dr. Bridgman suggested that it is not a common idea that there are still regions in which the man of science is groping his way and knows that he has not yet found the answers. Failure to realize this is one reason for the impatience of people with the scientific point of view and for the urge to return to a more humanistic outlook. Among such unsolved problems, Dr. Bridgman gave as examples that of the 'observer' in quantum physics and the growing concern with the basic problem of what sort of thing a brain is. One of the results which is beginning to emerge from cybernetics is a realization of the extent to which our conscious activities have to be selected from the overwhelming number of potentialities. The problem becomes not to find the absolute truth but to find how to do the best we can with what we have. Moreover, in psychology the new approach to the nature of perception is forcing on us the simple realization that all our conscious thinking is done in terms of perceptions, and we are now asking whether in the domain of ordinary experience the mould of space and time into which perception pours our world is a good mould. Dr. Bridgman believes that our task is to find the present status, in the light of all the insights now available to us, of such fundamental concepts as human rights, freedom, equality, duty and justice, and in the light of these insights to strengthen if possible, or to revise if necessary, the conceptual foundation of our social and political system. This task will demand a long campaign of education and the slow development of new intellectual techniques by a process involving much trial and error.

Reviewing more concrete aspects of the situation, Dr. Bridgman believes that analysis of the processes in a democratic society will in this way lead us to a society in which the relation between society and the individual is based on mutual advantage and service. Only exceptionally will it involve honouring minimum claims on the community whether or not any return is made; but it will also involve a revision in the philosophy underlying the system of taxation. Finally, it will place emphasis on two virtues: the repugnance of the individual to exercise force against his neighbour for his own advantage, and the imagination that can sense the significance of the simple underlying processes and relations so easily lost to sight under the complexities of modern life—or, in other words, intelligence.

* The Task before Us. By P. W. Bridgman. *Proc. Amer. Acad. Arts Sci.*, **83**, No. 3, ii+95–112 (1954). 50 cents.

THE OIL INDUSTRY

THE oil industry is one which could be said to be less than a hundred years old, or more than two thousand.

It seems probable that it was an ingenious Chinaman who first drilled a hole into the earth's surface. He was in search of salt water and natural gas which he could use as the fuel to evaporate the water to yield salt. In the process he or his successors at times bored down to three thousand feet and incidentally struck oil. They had no use for the oil except as a lubricant (*Esso Magazine*, **3**, No. 11; Spring, 1954).

The rig these Chinese devised is basically not unlike the cable rig used to-day; it sometimes took them ten years to drill a deep hole with their rigs.

Drake used the cable rig method when drilling the world's first commercial oil well in 1859. It was fortunate that he made his attempt in Pennsylvania rather than in Texas, because when the drillers got to Texas they encountered softer rock formations in which the simple cable rig was useless; the sides of the holes caved in as fast as the bits pounded through. As a result the rotary rig came into being; with this a hole is drilled through rock instead of being pounded through. A length of piping with a 'bit' on its end is gripped and rotated like a carpenter's drill. Mud, forced down the pipe, comes to the surface again in the space between pipe and hole, thus sealing off loose formations as the hole is drilled and bringing the cuttings to the surface. Two-thirds of wells sunk to-day are drilled by rotary rigs.

The drill pipe has greater precision than the cable for deeper holes; it also goes down straighter. This is important to-day, when wells are being drilled deeper every year.

During the Second World War there was not enough easily located shallow oil to keep industry and machines operating. New sources had to be

found. The drillers' bits now probed the rock formations of the Eocene and Oligocene ages; soon wells were being drilled to 12,000 ft. To-day, in the United States alone, ninety-seven wells are being operated at depths below 15,000 ft., of which twenty-two were drilled last year.

Difficulties increase, and costs multiply, with greater depths. (A 15,000-ft. well is three times as expensive as one of 10,000 ft. It may cost anything up to £400,000 to drill.) The strains imposed on rigs at a depth of two or three miles are vastly greater than with more shallow wells. Derricks have to be of much heavier construction to take the weight of the drill pipe and to hoist it up out of the hole. The heat at 15,000 ft. seriously interferes with the effectiveness of the normal drilling muds. Bits wear out more quickly owing to the greater density and hardness of the deep rock formations. Pipe that is fully adequate to drill to 5,000 ft. will twist at double that depth and drill crooked holes. The recent use of diamond bits for deep-hole drilling has eased the problem.

The world's deepest well had reached 21,482 ft. a little time ago when it was halted by a core stuck at the bottom and the drill pipe stuck at 12,000 ft. The core will reveal whether the well has reached formations of the Oligocene age. If it is still in shales of the lower Myocene age, drilling may be discontinued—with no oil found.

One of the most interesting of recent developments has been the adoption of directional drilling, the process whereby the direction taken by the bit can be changed while drilling is in progress—or the well can be drilled from the start at a chosen angle from the vertical. By this technique it is possible to deflect a hole from an unproductive to a productive part of an area and so save the time and cost of drilling again from the top; the hole can be deflected around particularly hard and difficult underground formations; a fire at a well can be brought under control by drilling a slanted relief well into it; by the same means one can drill under the sea from dry land.

The angle of drift is effected by means of a tool called a whipstock; this is a 'cone' which is lowered into the hole base first with its apex pointing upwards. A drilling bit will always follow the line of least resistance and, when it encounters the apex of the cone, it is naturally deflected from its vertical path at an angle, the angle being dictated by the shape of the whipstock used. Normally, the full angle to which it is intended to deflect a hole is made by a series of whipstock operations, the drift being increased 2–3° every hundred feet until an average angle of 10–45° has been obtained. Directional drilling programmes have been known to achieve a drift of 80° to a vertical depth of 8,000 ft.

Drilling practice is never static. The direction of advance has been and will be towards the automatic rig. The most difficult task has always been the racking of the drill pipe as it comes out of the hole in sections of ninety feet or more. Steel arms at various heights have now been evolved to do this automatically. Unscrewing the pipe joints also taxes the strength of the operators. Chains on winches have been used for twisting the pipe, but power-driven 'tongs' have done this by the push of a lever. To speed drilling a jet bit has been produced.

The greatest depth at which oil has been discovered is 17,895 ft. It is hoped that much more will be discovered below 20,000 ft.

SELECTION OF SUPERVISORS

In June 1948, the National Institute of Industrial Psychology's Foremanship Research Group conducted an experimental selection procedure in a large heavy-engineering works in Scotland. Two different selections for promotion to supervisory positions were made from a field of 110 candidates, obtained by advertisement within the firm. The first selection was made by management by their customary method of review and nomination; in the second, from the same field, systematic methods were used, including biographical history sheets, recommendation forms, intelligence tests, interviews, group discussion sessions, and a final selection panel. The latter procedure was carried out by members of the management with the advice and assistance of a member of the staff of the National Institute of Industrial Psychology.

After two years a check was made and gradings by the selection panel for the 44 men regarded as worth serious consideration for promotion correlated $0{\cdot}68 \pm 0{\cdot}08$ with assessments made on these men by their managers two years after the original selection. This was an encouraging result in comparison with the poor prediction, $0{\cdot}23 \pm 0{\cdot}14$, obtained by management's normal procedure. Another check has now been made by J. D. Handyside and D. C. Duncan some four years and five months after the original selection experiment*.

Two criteria were available against which to assess the efficiency of selection: first, ratings by managers who were in a position to assess the performance of the men concerned; and, secondly, whether the men had been promoted twice, once, or not at all during the four and a half year period.

Management's customary method of selection consisted of short interviews by the candidates' managers and discussion among managers who could be expected to know the men reasonably well. The results of the experimental evaluation of this method indicated that it was defective to a startling degree.

It appears from this experiment that a combination of existing, fairly elementary, selection techniques permits prediction of supervisory success—as measured by management criteria—just about as well as the uncertainties of the criteria allow. Nevertheless, there is a need to improve the economic efficiency of the selection methods.

* *Occupational Psychology*, **28**, No. 1; January 1954.

GULMARG RESEARCH OBSERVATORY

By Prof. P. S. Gill

Director of the Observatory and Head of the Department of Physics, Aligarh Muslim University

With the development of the subject of cosmic radiation the need for stations at various heights and in different parts of the world has become increasingly important. Previously, the high-altitude research stations were used for astronomical, astrophysical, meteorological and terrestrial magnetic measurements; but during recent years these stations have become mainly associated with the work in cosmic rays. In the Americas, a number of high-altitude research stations have been established through the efforts of cosmic-ray investigators, some of which—Mount Evans, Echo Lake, Climax, Mexico

City and Huancayo—are well known; in Europe, too, there are a number of stations, the best-known being the Jungfraujoch in the Alps.

Within the past fifteen years, cosmic-ray studies in India have been initiated in a number of institutions, and naturally the need for establishing a station at a height where it is convenient to work throughout the year has been felt. The Meteorological Department has a station at Kodaikanal (about 7,000 ft.) in southern India, close to the geomagnetic equator. The geographical position of India for the study of cosmic rays is of special importance, because one can go from the geomagnetic equator to about 25° N. within a narrow range of longitude. The effects of the earth's magnetic field are strongly felt in this part of the world, for the intensity of cosmic rays varies rapidly with geomagnetic latitude within the intermediate latitudes.

Aligarh Muslim University was one of the institutions in India where work on cosmic rays was initiated in 1949. The cosmic-ray group thought it necessary to establish a station in the Himalayas at a convenient height, and, after considering various sites, it was finally decided that such a station should be located at Gulmarg in Kashmir. The Government of Jammu and Kashmir provided ample facilities for the opening of this laboratory, and a formal agreement was signed with the Government in the year 1951. The observatory was officially opened this year on April 4 by Prof. A. H. Compton, chancellor of Washington University (see *Nature*, May 1, p. 805). Spacious accommodation at Gulmarg has been provided to house the laboratory, its staff and visitors. The research observatory is run jointly by Aligarh Muslim University and the University of Jammu and Kashmir under a managing committee consisting of representatives of both these institutions. The decision to establish the observatory at Gulmarg was based on many factors, one being that Gulmarg is one of the finest hill stations in Kashmir with a very fine golf course, and another that it is easily accessible and, if need be, it is possible to keep the observatory open for the whole year. In the words of Prof. A. H. Compton: "The height of 9,000 ft. is as great as persons unaccustomed to altitude can work without discomfort, and is adequate for many types of study that cannot be performed effectively at sea-level. The altitude is comparable also with that of most of the high-altitude laboratories elsewhere with which it is important to compare results, for example, Mexico City (about the same magnetic latitude) at 7,500 ft., Huancayo, Peru, at 10,500 ft., Echo Lake, Colorado, at 10,000 ft., and Jungfraujoch, Switzerland, at 11,300 ft. The location is also suitable as a base station for work at higher altitudes, up to 11,000 ft. at Khillan Marg, one hour distant, and up to 14,000 ft. at Apharvat, three hours distant. These locations are as high as any stations at which high-altitude research is now regularly being done".

The research observatory is easily accessible, and a 'jeep' can go right up to the gate of the observatory. To get to Gulmarg, one can fly from Delhi to Srinagar, the capital of Kashmir, the flight lasting three hours, and from Srinagar Gulmarg is twenty-eight miles away. Alternatively, there is a train service up to Pathankot, from where one can take a bus to cover the 275 miles to Srinagar. A good road goes from Srinagar to Tangamarg, which is within four miles of Gulmarg, and this road is now being extended for 'jeeps' and trucks right up to Gulmarg. The proposed tunnel under the Banihal Pass will keep the road open to Srinagar throughout the year.

The physical details of the observatory are as follows: altitude, 9,000 ft.; geographic latitude, 34° 03′; geomagnetic latitude, 24° 36′; geographic longitude, 74° 24′; average barometric pressure, 707 mb.; maximum temperature, 80° F.; minimum temperature, 30° F.; and average temperature, 60° F. At present the electric power is not satisfactory, as the supply only allows for 5 kW. and the load is such that the voltage fluctuates considerably; also, the alternating frequency is 25 c./s. The Kashmir Government intends to instal a new generator which will give 220 V., 60 c./s., within a few years. During the working season, Nedou's Hotel remains open to visitors, and there are also a number of small hotels and eating places. There is a market for buying provisions. Horses, ponies and labourers are available in abundance at fairly reasonable rates.

The resources of the observatory are meagre, as the two co-operating universities are unable to provide adequate funds at present. It is hoped that in due course a small workshop will be installed. The managing committee of the observatory has empowered the director to allow Indian and foreign investigators to carry out work at this altitude and latitude, if such requests are made. It is intended to develop the observatory into a general-purpose high-altitude laboratory; though it is not meant solely for the cosmic-ray studies, this is the main field in which work has been in progress.

SOCIAL FEEDING BEHAVIOUR OF BIRDS

AUSTIN L. RAND, of the Chicago Natural History Museum, has published a paper with the object of illustrating how certain behaviour patterns in birds may have originated out of general tendencies and evolved from simple to complex patterns (*Fieldiana:* Zoology, **36**, No. 1). Social feeding habits of birds, outside the breeding season, are considered from the point of view of possible stages through which the more complex patterns have evolved. Behaviour patterns are examined and compared, and arranged according to their similarity in organization and usefulness. This discloses a number of series, each starting with the simple and becoming more and more complex.

Intraspecific social behaviour is examined first, as it is simpler, and the factors involved tend to be more easily seen. Gregariousness is very pronounced in birds, and seems to be the main starting point for these associations. This flocking could be a disadvantage when food is limited; but various modifications or organizations of the flocks exist that not only cancel out such disadvantages, but also make a position in the organized flock more advantageous than solitary feeding. The most obvious of these are: spacing out of the flock to reduce competition; the leading of some individuals to food by others going to it; the beating or driving of coverts, which flushes prey into accessibility; combining of individuals to capture, kill or otherwise secure food already sighted.

The feeding associations of birds transcend species limits, and many are concerned with animals other than birds, including man and his extensions such as ships. The bird seeking the association is often the

chief beneficiary, through the beating activities, the providing of scraps, and the providing of parasites and even flesh of its own body by the animal accompanied. Another series in this category is the pilfering or robbing of one species by another.

In flocks in which numerous species of birds keep together, many of the factors involved in the simpler cases mentioned above are discernible, and it is probable that several may work together, reinforcing each other. Protection from predation by flocking is probably of no great importance.

Data are given to show the extreme acuity of birds in seizing on small elements in their environment that provide food benefits. They show that such occasional benefits may lead to new habits; that new habits are still arising; and that simple or occasional associations in some species are more complex or regular in other species.

It is possible to see how complex behaviour patterns evolved if psychological processes of a low order are postulated, satisfaction or benefits being associated with the presence of certain conditions such as variability among the birds to recognize such associations and the selection of certain favourable variations until they become a part of the normal behaviour pattern.

The rapidity with which new patterns develop, and similar patterns that evolve in unrelated birds, indicate that these behaviour patterns are not necessarily phylogenetic. Despite this, these patterns indicate the stages through which complex behaviour probably passed and how it originated.

Some mixed bird parties increase competition between species, offsetting some at least of the mutual aid of the associations.

MICROSEISMS

THE name microseisms was given in 1870 by Father T. Bertelli to the ground unrest of wave period from about 1 sec. to 10 sec. and variable amplitude (about 5 μ) registered by seismographs. This movement is now studied because of its intrinsic interest and also pragmatically because of its meteorological associations. A symposium on the subject, organized by Dr. R. C. Gibbs, was held at Arden House, Harriman, New York, during September 4–6, 1952, under the sponsorship of the Office of Naval Research and the Geophysical Research Division of the United States Air Force*. It was attended by more than thirty specialists in the field (one each from the Netherlands and Sweden, two from Great Britain and the remainder from the United States), and the report has just been received. It contains the following eight papers together with the discussions on them: sketch of the history of microseismology, by J. B. Macelwane, *S.J.*; tripartite stations and the direction of approach of microseisms, by J. E. Ramirez, *S.J.*; amplitude distribution of storm microseisms, by Marion H. Gilmore; microseismic period spectra and related problems in the Scandinavian area, by Marcus Båth; Can sea waves cause microseisms ?, by M. S. Longuet-Higgins; storm and surf microseisms, by F. W. van Straten; the ocean as an acoustic system, by Frank Press and Maurice Ewing; on theories of the origin of microseisms, by J. G. Scholte.

* Symposium on Microseisms. (Publication 306.) Edited by James T. Wilson and Frank Press. Pp. vii+125. (Washington, D.C.: National Academy of Sciences, National Research Council, 1953.) 1 dollar.

It appears to be generally accepted that microseisms, more frequent in winter than in summer, are elastic waves travelling at about 100 miles/min. over the surface of the earth and not body waves through the earth. They appear to be largely Rayleigh waves together with some Love waves, and to be of different wave forms as well as of different periods. Those of period 2 sec. and less may be due to local winds or may be man-made. Group microseisms of period 3–10 sec., exhibiting beats, appear to be almost always of marine origin, and those of period 1 min. or more to occur at the time of frost near stations. The symposium was mostly concerned with problems about the group microseisms of period 3–10 sec.

Historically, it was suggested by Wiechert that these may be due to the beating of surf on a rocky coast, and later by others that they were formed near the centre of a storm at sea. Tripartite stations were used by J. J. Shaw in England (1918–22) and more accurately by Gilmore, among others, in the Caribbean (1944) to get cross-bearings, in an attempt to track the centres of microseismic disturbances. This method has not proved entirely satisfactory, supposedly because of geological barriers such as deep-seated faults, and the irregular passage and attenuation of waves by geological formations. Gilmore is now attempting to detect microseismic centres when they begin; to follow the centres once they have formed; and to get an idea of the energy at all points in the path, by empirical amplitude relationships.

The intimate connexion between events in air (such as microbarometric pulsations, gustiness, barometric gradients and cold fronts), events in the sea (waves, standing waves, surf pressure) and microseisms is not fully understood, but good progress is being made at some points. It has been shown by Deacon and Longuet-Higgins, following work by Miche, that second-order terms in the equations of the pressure field produced by standing waves at sea integrated over a sufficiently large area could quantitatively account for microseisms of half the period of the standing waves; and such microseisms have been shown to exist at Kew. Ocean waves of period 16 sec. produced 8-sec. microseisms at Kew, just as $\frac{1}{2}$-sec. waves in an experimental tank produced $\frac{1}{4}$-sec. microseisms in the bottom of the tank.

Standing waves in the ocean could conceivably be produced by interference caused by a fast-moving low air pressure area, or by coastal reflexion of ocean waves; but this does not seem to be the whole picture since, on the western side of the Atlantic Ocean, Frank Press and Maurice Ewing (Columbia University) conclude from their observations that "(1) Frontal microseisms are generated very soon (often abruptly) after a cold front passes seaward from land, with no obvious correlation to prior wind and sea conditions. (2) A relatively narrow spectrum of periods appears to be generated by a front, cyclone, or hurricane at a given time when the disturbance is over an area of uniform water depth. Characteristic periods of microseisms can be related to generating areas in the ocean. (3) As a front recedes from shore, the spectrum gradually shifts to longer periods, and becomes fairly constant after deep water is reached. (4) Cold fronts and air masses following them can generate microseisms whereas warm air masses preceding the cold fronts fail to generate microseisms even when strong onshore winds are present. (5) In many cases there are no obvious correlations between swell and surf conditions and microseisms. (6) Micro-

seismic energy is dissipated by a profound crustal discontinuity at the edge of the continental shelf. Hurricanes crossing the edge suddenly generate larger microseisms".

Observations are still being made at observatories throughout the world, in conformity with the microseismic research project of the Section of Seismology of the International Geodetic and Geophysical Union, which was initiated in 1952, and detailed observations have yet to be made of the energy of the gusts of wind at sea likely to be associated with microseisms, and also the pressures and variations of pressure at great depths on the bottom of the ocean likely to be associated with microseisms. It is hoped that, with further observations and consideration, more progress will be made, particularly with the air–sea energy transfer.

ERNEST TILLOTSON

BASIC RESEARCH ON ODOUR

TO say that the sense of smell has been neglected as an object of study, because of the formidable experimental difficulties involved, particularly when examining the peripheral aspects of the sense, is of course to state a platitude. It would appear that the newer techniques of measuring minute quantities of substances might, however, prove rewarding when applied to the investigation of olfaction, and might be the means of stimulating renewed interest, especially in these neglected peripheral phases. It was possibly with such thoughts in mind that a conference was organized in April 1953, jointly by the New York Academy of Sciences and the American Society of Heating and Ventilating Engineers, for although practically every aspect of olfaction was then reviewed, greatest emphasis was placed on the peripheral phases. The edited versions of the papers read at the conference have now been published in the *Annals of the New York Academy of Sciences**. No doubt because of the participation of the latter Society, papers on technological problems occupy a prominent place, more prominent than would probably be the case at a similar conference in Britain. The whole report, therefore, provides an up-to-date review, and a short guide to the literature, of both technical and laboratory work carried out recently on odours and olfaction.

A major object of any conference such as this is to throw up ideas, and a reasonable degree of speculation is not altogether undesirable. However, this can be overdone, and unfortunately several of the participants did not resist the temptation to explain how, on theoretical grounds, odours might be converted into nerve impulses. While reading some of the papers, one was reminded of Homer Smith's comment, made when he was reviewing the earlier concepts of renal function, that the history of science has been one of rival over-simplified theories, to which fault has been added that of insufficient experimental work. Parts of the report on this conference show that our grandfathers may have been no worse than ourselves.

The first part of the conference was concerned with the problem of odour in industry; the papers were, in fact, devoted to the practical problems of how to prevent food, tobacco, paper and the interiors of buildings from being contaminated by odoriferous substances. As there is so little basic knowledge available as to either the behaviour of the odoriferous substances, or the absorbent properties of the contaminated materials, the problems are attacked along empirical lines. The cause is traced, and if it cannot be removed then various odour neutralizers or modifiers are tried until the one which is most satisfactory in the circumstances has been found.

The next major section of the conference was entitled "Problems of Odour Research from the Viewpoint of the Scientist", with contributions from a physiologist, a psychologist, a physicist and a chemist. J. Greenspan outlines some of the newer physical methods for measuring concentrations as low as parts per million; but later in the conference, R. L. Kuehner reports that such methods are still not as satisfactory as would be desired, and he suggests the use of other methods which depend upon subjective threshold sensations, or upon chemical absorption of the odorant. L. M. Beidler, the physiologist, points out, too, that by analogy with the investigations on taste a method of measuring concentrations in the air, and of controlling such concentrations, would not necessarily enable the ultimate nature of the stimulus to be understood, for the nature of the receptor is so important. J. B. Sumner, at least, is aware that the generally accepted view of odours being transmitted by volatile particles in the atmosphere is no more than a hypothesis, although undoubtedly a much more satisfactory one than others depending upon such an alternative as infra-red radiation.

The third section was concerned with the status of our present knowledge of the olfactory nervous system, and contained papers of rather uneven quality. There was in one paper a tabulated list of the functions of the turbinate bones; while another paper, which offered yet a further hypothesis of olfaction, based upon information theory this time, opened with a quotation followed by the comment, "In these words, Titus Lucretius Carus developed the first atomistic theory of olfaction in about 47 B.C. This year of 1953 marks the two-thousandth anniversary of this theory". On the other hand, K. H. Pribram and L. Kruger's review of the "Olfactory Brain" is particularly satisfying, and, at the risk of appearing invidious to the writers of other equally satisfactory articles, one may regard it as one of the most important papers of the conference and suggest that it is not to be overlooked. Their final conclusion justifies quoting: ". . . the 'olfactory brain', as defined, is not primarily olfactory, though parts of it serve olfactory functions. Nor is the current conception of a 'visceral brain' more tenable though viscero-autonomic functions are also served. It is clear that the formations in this portion of the brain, though they share several characteristics, are not, at this time, usefully thought of as *a* brain serving any *one* function. Since at least three distinct systems can be delineated, each might profitably be investigated before an attempt is made to define what functions they have in common". In the third section also, M. M. Mozell and C. Pfaffman contribute a review of the afferent neural processes, largely concerned naturally with Dr. E. D. Adrian's recent work, while V. G. Dethier has a most interesting paper on the physiology of olfaction in insects.

The rest of the conference was mainly devoted to techniques of measuring and identifying odours, with a consideration of some of the results obtained. This section might preferably have been placed earlier in

* "Basic Odour Research Correlation", by A. R. Behnke and 38 other specialists. *Ann. N.Y. Acad. Sci.*, **58**, Art. 2, 13–260 (1954). 3.50 dollars.

the conference. Most of the workers concerned with the practical problems of eliminating odours prefer to use subjective methods; but there is here also a full discussion of objective methods. It has been suggested that the olfactory mucosa is sensitive to concentrations as low as 10^{-13}; if this is true, there is some considerable way to go, and much fundamental research is required, before adequate objective methods are available. But this is not to deprecate the very valuable and important work of the present-day pioneers.

H. Sosnowick

AGE OF PARENT AND CHARACTER OF OFFSPRING

THE relations of an offspring to its parents are complex, and the ways in which a parent may influence the character of its offspring are many. This is especially true among the higher animals; but even when we turn to lower animals and to plants the parent–offspring relation, if simpler, is still far from simple. Though, as genetics has emphasized, the primary endowment is the complement of nuclear genes, an individual also receives from its parents its initial cytoplasm—mainly, but not necessarily exclusively, from its mother. The cytoplasm so received may contain particles of a genetic or semi-genetic nature (plasmagenes of various kinds), nutritional materials, protective substances and agents of disease (such as viruses). It is a complex endowment as yet by no means fully understood. Nor is the cytoplasm the only avenue of supply of food materials, protective substances and disease risks. The close association of offspring with parent during early life, especially in higher animals, plays its part in the nutrition, protection and disease relation of the offspring and, of course, also in its education.

Our understanding of these various links between the generations is not equal. Classically the geneticist has concerned himself primarily with the nucleus and the genes it carries, setting other aspects aside as secondary to the main problem. Initially this was an essential restriction, but of recent years especially the study of the nuclear genes has itself guided attention to the cytoplasm, to the immunological relations between mother and child, and to the effects of maternal nutrition; indeed, to the whole complexity of the parent–offspring relation. Thus as the genetical framework has become clear, the way has opened up to a co-operative attack on the broader problem by all the many interests which are concerned.

Both the complexity of the problem and the many types of approach which can be made to it are brought out by a recent symposium on "Parental Age and Characteristics of the Offspring" held by the New York Academy of Sciences*. Although in his introduction E. V. Cowdry chiefly emphasizes the effects of age of mother and father on longevity in the offspring, he recognizes in his summary that this provides only a superficial common denominator for the many phenomena described in the nineteen contributions to the symposium, and he stresses the need for a better understanding of the mechanisms which underlie the effects we observe. The observations reported cover a very wide field. Asexually produced progeny in plants are discussed alongside parthenogenetic rotifers and the sexual offspring of mammals. Longevity, germination characters of seeds, mutation-rates, the expression of congenital malformation in men and mice, mongolism and the sex ratio in man, fibrocarcinoma and leukæmia in mice, the consequences of ageing gametes before fertilization, skeletal characters, spotting, the results of altering a mother's physiology during pregnancy, and seasonal influences, are all to be found among the subjects considered. As might be expected, the importance of the mother's age emerges clearly as opposed to that of the father; but there is, again not surprisingly, little pattern to be discerned as yet even at the level of description of the phenomena. Suggestions can be, and are freely, made as to the underlying causation. Hormonal changes, cytoplasmic entities, antibody levels, viral effects, biochemical adjustments, and alterations in crossing-over with age, are all brought in, and the susceptibility of polygenically determined variants to non-nuclear effects is emphasized. But the value of this symposium lies in the problems it poses and the clues it offers rather than in the explanations it achieves or the mechanisms it exposes.

Two papers are especially interesting in their bearing on the nature of somatic ageing. The first, by A. I. Lansing, describes experiments with the rotifer *Philodrina citrina*, which, being parthenogenetic, is unlikely to show any significant amount of variation mediated by nuclear genes within its progenies. Separate lines were developed, differing in the age of the mother at the time of production of the eggs from which the next generation was raised. With eggs from adolescent mothers the longevity of the offspring tended to increase as the generations went by. The lines in which eggs were taken from middle-aged or senile mothers, on the other hand, showed a decline in longevity until they died out after five and three generations, respectively. The change is reversible by reversal of the selection. Furthermore, there is a close relation between growth and ageing, the ageing factor appearing in the eggs at the time when the mother ceases growth. Accelerated ageing accelerates growth but decreases maximal size, while retarded ageing retards growth and increases maximal size.

In the second paper E. Ashby and E. Wangerman describe experiments with clones of the water-plant *Lemna minor*. The fronds of this plant reproduce by asexual buds, the daughters so produced being successively smaller as the mother frond ages. It appears from extrapolation that the age of mother at which daughter size would be zero is the age of death. Thus the meristems grow old with the mother. As with the rotifers the process is cumulative and reversible, for first daughters are larger than their mothers where these mothers were themselves from old parents and therefore small.

The regularity and similarity of behaviour in the rotifer and the plant are striking. Though clearly not dependent on genetic segregation, the responses to selection resemble in several respects those which can be obtained with polygenic variation. Can they depend on a multi-particulate cytoplasmic system, related ultimately to the nucleus, but capable of change independently of the nuclear genes? Though it is too early to do more than speculate, these papers suggest an experimental approach which might materially advance our understanding of the changes which go on during development and ageing.

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* "Parental Age and Characteristics of the Offspring", edit. L. C. Strong. *Ann. N. Y. Acad. Sci.*, **57**, 451–614 (1954).

INCORPORATION OF HALOGENATED PYRIMIDINES INTO THE DEOXYRIBONUCLEIC ACIDS OF *BACTERIUM COLI* AND ITS BACTERIOPHAGES

THE pyrimidine 5-bromouracil may be regarded as a structural analogue of thymine in which the methyl group of thymine is replaced by a bromine atom. Weygand, Wacker and Dellweg[1] showed that the inhibition of growth of *Streptococcus faecalis* R. by 5-bromouracil is competitively reversed by thymine. Using 5-bromouracil containing the isotope bromine-82, they demonstrated the incorporation of 5-bromouracil into the nucleic acids of *S. faecalis*, although they did not show whether the analogue was present in the ribonucleic or deoxyribonucleic acids.

We have found that, under conditions in which *Bacterium coli* requires thymine, 5-bromouracil and 5-iodouracil are extensively incorporated into the deoxyribonucleic acids of the bacterium and its bacteriophages, replacing thymine residues in the nucleic acid molecule. No incorporation of 5-bromouracil into the bacterial ribonucleic acid could be detected.

B. coli strain *B* was grown in a glucose – ammonium sulphate medium containing sulphanilamide (1 mgm./ml.), vitamin-free casein hydrolysate (1 mgm./ml.), xanthine (25 μgm./ml.) and varying amounts of thymine. In this type of medium, growth of *B. coli* has been found to be dependent upon the amount of thymine[2]. Two to four hours after the addition of 5-bromouracil or 5-iodouracil, the mean generation time of bacteria in this medium is increased and thereafter remains approximately constant. The degree of inhibition by 5-bromouracil increases with the ratio 5-bromouracil/thymine; but is not affected by uracil. After inhibition by either analogue, the proportion of bacteria giving colonies on nutrient agar is reduced.

The bacteriophages T_2r and T_6 were grown on *B. coli B* in the above medium containing 8×10^{-5} *M* thymine by infecting with three bacteriophages per bacterium at a bacterial density of $1{\cdot}5 \times 10^8$/ml.; 2×10^{-3} *M* 5-bromouracil or 5-iodouracil was previously added at a bacterial density of 10^8/ml. Although it has been reported that in a similar medium *B. coli* infected with T_2, T_4 and T_6 bacteriophages fails to lyse[2], under our conditions 90 min. after infection with T_2r the bacteria lysed with the production of bacteriophages. T_2r was purified by the method of Herriott and Barlow[4] and T_6 by differential centrifugation and treatment with deoxyribonuclease.

Deoxyribonucleic acid was prepared from *B. coli* by the method of Smith and Wyatt[5] and from T_6 by treatment with 0·1 *M* sodium citrate buffer *p*H 7 at 45°. Intact T_2r bacteriophage and deoxyribonucleic acid from *B. coli*, both grown in the presence of 5-bromouracil, were hydrolysed in 72 per cent w/w aqueous perchloric acid[6] and the hydrolysates run on two-dimensional paper chromatograms in *iso*propanol – water – hydrochloric acid[7] and *n*-butanol – water – ammonia[8]. In both hydrolysates, 5-bromouracil, identified by paper chromatography, electrophoretic mobility and ultra-violet spectroscopy, was found to have replaced quantitatively part of the thymine found in normal T_2r and *B. coli* nucleic acids (Table 1).

Table 1. MOLAR PROPORTIONS OF THYMINE AND HALOGENATED PYRIMIDINES IN DEOXYRIBONUCLEIC ACIDS FROM *B. coli* AND T_2r GROWN IN THE PRESENCE OF 5-BROMOURACIL AND 5-IODOURACIL

The nucleic acids were hydrolysed in perchloric acid, and in the case of T_2r, Wyatt's data (ref. 9) were used to allow for the 5-hydroxymethyl cytosine.

Deoxyribonucleic acid	Moles/100 moles estimated bases			
	Thymine	5-Bromouracil	5-Iodouracil (estimated as uracil)	Thymine + halogenated pyrimidine
B coli B	27·2	—	—	27·2
B. coli B '5-bromouracil'	16·0	8·7	—	24·7
B. coli B '5-iodouracil'	19·4	—	4·5	23·9
T_2r	30·5	—	—	30·5
T_2r '5-bromouracil'	6·4	24·1	—	30·5
T_2r '5-iodouracil'	15·4	—	14·5	29·9

The relative proportions of the other bases remained unchanged.

Deoxyribonucleic acids from *B. coli* and T_6 grown in the presence of 5-bromouracil were hydrolysed to the 5′ nucleotides with deoxyribonuclease and rattlesnake venom diesterase. The separation of 5-bromouracil deoxyribonucleotide was facilitated by the fact that 5-bromouracil bears a negative charge at *p*H 9 (presumably due to the dissociation of the 2 or 6 (OH) group) while the other bases are uncharged. Paper electrophoresis of both hydrolysates in 0·05 *M* borate buffer *p*H 9 gave, in addition to a band containing the four natural nucleotides, a second band migrating more rapidly towards the anode. This contained a substance with an ultra-violet absorption spectrum in 0·1 *N* hydrochloric acid similar to that of 5-bromouracil but shifted about 3 mμ towards the longer wave-lengths (λ max., 279 μ; λ min., 244 μ). On hydrolysis with perchloric acid, this gave 0·96 mole 5-bromouracil/mole phosphate. We conclude that the substance is 5-bromouracil deoxyribonucleotide. After hydrolysis of the *B. coli* deoxyribonucleic acid with deoxyribonuclease and snake venom diesterase and 5′ nucleotidase, a substance with the expected properties of 5-bromouracil deoxyriboside was isolated.

Perchloric acid hydrolysis of T_2r bacteriophage or deoxyribonucleic acid from *B. coli* grown in the presence of 5-iodouracil gave in addition to the usual bases a substance identified by chromatography and ultra-violet spectroscopy as uracil. The relative proportion of thymine to the other bases was decreased such that the sum of the uracil and thymine equalled the expected amount of thymine (Table 1). It was then found that 5-iodouracil, although stable alone to the perchloric acid hydrolysis, in the presence of deoxyribonucleic acid preparations is converted to uracil. Enzymic hydrolysis of the *B. coli* deoxyribonucleic acid followed by paper electrophoresis at *p*H 9 gave a substance with the expected electrophoretic mobility and ultra-violet absorption spectrum of 5-iodouracil deoxyribonucleotide. On hydrolysis with perchloric acid this decomposed giving uracil. While as yet lacking direct evidence from the isolation of iodouracil itself, we conclude that the uracil found in the perchloric acid hydrolysates of the deoxyribonucleic acids is derived from 5-iodouracil incorporated into the nucleic acids. We have also found that 5-chlorouracil will replace thymine residues in the deoxyribonucleic acid of thymine-requiring *B. coli*.

Preparations of T_2r and T_6 containing 5-bromouracil or 5-iodouracil had the same ultra-violet absorption

spectra as normal preparations, and electron microscopical examination of the T_2r 'bromouracil' preparation showed particles of normal structure. However, the ratio (bacteriophage titre/optical density at 260 mμ) showed that the various 'bromouracil' and 'iodouracil' bacteriophage preparations contained 50–98 per cent non-infective particles. For example, in a preparation of T_2r in which 79 per cent of the thymine residues were replaced by 5-bromouracil, 70 per cent of the particles did not give plaques when plated on *B. coli B*.

As 5-bromouracil or 5-iodouracil was present before and after infection, it is reasonable to assume a nearly random distribution of halogenated pyrimidine residues among the bacteriophage particles. It thus seems likely that particles containing 5-bromouracil and 5-iodouracil are infective, but that the probability of successful infection by a virus particle decreases with increasing incorporation of the analogue.

The incorporation of bromine and iodine atoms into specific positions in the deoxyribonucleic acid molecule may be of considerable help in elucidating its structure by means of X-rays. This possibility is being investigated by Dr. M. F. Wilkins and his colleagues at King's College, London.

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The hypothesis that the composition of the whole deoxyribonucleic acid is characteristic of the species from which it was derived[1] does not necessarily imply that this composition is unchangeable. However, the constancy of composition in cumulative data (for a review see ref. 2), as well as the finding that the deoxyribonucleic acid of a thymine-requiring strain of *E. coli* does not change its thymine content when the cells were grown on a large excess of thymine[3], strongly suggested that the composition of deoxyribonucleic acid is independent of the environment, as, it seemed, would need to be the case for a heredity determinant.

The findings[4–8] that the unnatural purine azaguanine and pyrimidine thiouracil can be built into ribonucleic acid prompted investigation into the possibility of such building into deoxyribonucleic acid. With purines (azaguanine, 6-mercaptopurine), the incorporation, if any, was extremely low[5,7,9]. On the other hand, Weygand *et al.*[10] found that a mixture of degradation products of deoxyribonucleic and ribonucleic acids from *S. faecalis R*, grown on a medium containing the radioactive unnatural pyrimidine 5-bromouracil containing bromine-82, yielded on hydrolysis a radioactive substance or substances of a chromatographic R_F value (butanol – water) similar to that of both thymine and 5-bromouracil. These investigators suggested that the 5-bromouracil, due to its steric similarity to thymine, was indeed built into deoxyribonucleic acid of *Streptococcus faecalis*. Radioactive 5-bromouracil was also taken up by non-dividing cells of *Streptococcus faecalis* and *Enterococcus* Stei, but little, if any, was taken up by *E. coli*[11].

Table 1

Strain*	I	II	
Preparation*	*a*	*b*	*c*
Molar ratios†			
5-Bromouracil to thymine	0·43	0·236	0·260
5-Bromouracil to cytosine	0·281	0·174	0·192
Thymine to cytosine	0·652	0·738	0·738
Thymine to adenine		0·752	0·760
Adenine to cytosine		0·985	0·975
5-Bromouracil + thymine to adenine		0·927	0·958
5-Bromouracil + thymine to cytosine	0·933	0·913	0·934

* See text.

† For strain II, recovery 92 per cent of nucleic acid phosphorus; guanine recovery was least satisfactory.

We have grown certain strains of *E. coli* on a medium containing 5-bromouracil and have isolated highly polymerized deoxyribonucleic acid in which 18–28 per cent of the thymine was replaced by 5-bromouracil. Strain I was the thymine-requiring mutant mentioned above[3]; strain II was a back-mutant to thymine independency. The behaviour of these strains is described in the following communication.

The cells were grown at 37° on nutrient agar or broth containing 5-bromouracil (100 μgm./ml.). This addition partially inhibits the growth of strain I but not of strain II. Highly polymerized deoxyribonucleic acid was isolated by two methods (Table 1): (*a*) from strain I by the method previously described[3]; (*b*) and (*c*) from strain II by a modification in which grinding is replaced by incubation with 3 *M* glycine followed by three extractions with 1 *M* aqueous sodium chloride; only the latter extracts were used for the recovery of deoxyribonucleic acid. In this method two preparations were made: (*b*) not treated with 'Norit' and not dialysed; it contained 10 per cent ribonucleic acid; and (*c*) treated with 'Norit' and dialysed as described before[3]; it contained less than 1 per cent ribonucleic acid.

The final viscous preparations were precipitated with ethanol; the fibrous precipitate in 3 mgm. aliquots was hydrolysed for 40 min. at 100° with 0·08 c.c. of 7·5 *N* perchloric acid[12], diluted to 0·2 ml., centrifuged and analysed by paper chromatography in two solvent systems: (1) in butanol – water the ratio $\frac{R_F \text{ 5-bromouracil}}{R_F \text{ thymine}}$ is 1·04; this usually does not permit the separation of these two compounds (compare ref. 10), but permits the separation of the two from other nitrogenous bases; (2) in butanol – ammonia the ratio $\frac{R_F \text{ 5-bromouracil}}{R_F \text{ thymine}}$ is 0·49; this permits easy separation of the two. Accordingly, the hydrolysate was first chromatographed in system (1), and the common spot of 5-bromouracil and thymine was then chromatographed in system (2); this was accomplished technically by using either two-dimensional chromatography, or a long strip of paper in step (1).

The final spots were extracted and the nitrogenous bases content determined in the Beckman spectrophotometer. The hydrolysate of deoxyribonucleic acid of strains I and II grown on 5-bromouracil

exhibited a spot (located by means of an ultra-violet lamp and special fluoroscope[12]) which in both solvent systems behaved exactly like pure 5-bromouracil, and, when extracted, showed an ultra-violet absorption spectrum identical with that of pure 5-bromouracil (in water, E max. at 276 mμ; $E(276)/E(290) = 1 \cdot 57$; in 0·1 N sodium hydroxide, E max. at 296 mμ). In addition, this extract containing 10 μgm./ml. base computed (ultra-violet spectrum) as 5-bromouracil inhibited the growth of strain I to the same extent as did pure 5-bromouracil (for details see following communication).

The results are summarized in Table 1. It can be seen that the thymine content was approximately a quarter to a third less (on cytosine basis) than in this and two other *coli* strains grown in the absence of 5-bromouracil (in which molar ratios of individual bases are close to 1[3]); this amount seems to be substituted by bromouracil (28–18 molar per cent of cytosine).

In such a study it is, of course, necessary to exclude rigorously the possibility that the 5-bromouracil was present in deoxyribonucleic acid merely as a non-chemically bound impurity. This possibility is contra-indicated by the corresponding deficiency in thymine; other control experiments are listed below:

(1) Normal deoxyribonucleic acid was dissolved in aqueous solution containing 5-bromouracil (100 μgm./ml.) and subjected to purification procedures for deoxyribonucleic acid, as described above. The hydrolysate of the final product contained no detectable 5-bromouracil.

(2) As can be seen from Table 1, the 5-bromouracil content of the dialysed (48 hr.) preparation (*c*), which contains less than 1 per cent of ribonucleic acid, is the same as that of the non-dialysed preparation (*b*), which contains 10 per cent ribonucleic acid; this makes it improbable that the bromouracil was present as a low molecular-weight component or as a component of ribonucleic acid.

(3) Prior to hydrolysis at 100° for 40 min. the deoxyribonucleic acid of strain II was hydrolysed (with 7·5 N perchloric acid) for ½ hr. at 37°. This procedure liberates all purines but no cytosine and only 4 per cent of thymine. No 5-bromouracil could be detected in the hydrolysate. The 5-bromouracil was liberated only after hydrolysis (100°, 40 min.), liberating pyrimidines from deoxyribonucleic acid. (Ribonucleic acid pyrimidines are little liberated in these conditions).

(4) The presence of 5-bromouracil as an integral component of deoxyribonucleic acid was suggested by the actual isolation of 5-bromouracil deoxyriboside. 25 mgm. of deoxyribonucleic acid (preparation *b*, Table 1) were digested for seven days at 30° with the malt nuclease preparation[14] which was recently found to produce deoxynucleosides in good yield[15]; the conditions were those employed in the latter paper. The digest was concentrated and analysed chromatographically as described above. Besides natural deoxyribosides, the chromatograms showed in both solvent systems an additional spot of R_F value similar to that of 5-bromouracil. The extract of this spot showed the presence of a deoxypentose[16]; the ultra-violet absorption spectrum exhibited a maximum at 279 mμ which, like thymidine[17] (but unlike thymine or 5-bromouracil), did not shift to higher wave-lengths in 0·1 M sodium hydroxide (E max. at 277 mμ). In addition, this extract containing 0·5 μgm./ml. nucleoside computed (ultra-violet spectrum and deoxypentose content) as 5-bromouracil deoxyriboside inhibited the growth of strain I (see following communication).

When the extract was hydrolysed with 7·5 N perchloric acid at 100° for 40 min., it yielded a substance identified as 5-bromouracil by its chromatographic behaviour, ultra-violet absorption spectrum, shift of spectrum in 0·1 N sodium hydroxide, and bacterial growth inhibition, as described above. All these data indicate that the unknown (before hydrolysis) was indeed 5-bromouracil deoxyriboside.

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E. coli containing 5-Bromouracil in its Deoxyribonucleic Acid

In the preceding communication we have reported that certain strains (I and II) of *E. coli*, when grown on a medium containing 5-bromouracil, build this unnatural pyrimidine into cellular deoxyribonucleic acid. Strain I was isolated[1] by one of us (S. Z.) from American Type Culture Collection No. 11117; the latter is a mutant produced by X-ray irradiation[2]. Strain I requires thymine for growth on a synthetic (asparagine) medium. It has been used for the thymine assay[3] and for the study of the effect of excess of thymine on thymine content in deoxyribonucleic acid[4]. Preliminary study[1] indicated that the thymine requirement can be replaced by thymidine or thymidylic acid but not by other natural constituents of deoxyribonucleic and ribonucleic acids.

We find that 8×10^{-7} M (0·1 μgm./ml.) thymine, 2×10^{-7} M thymidine and 2×10^{-6} M thymidylic acid represent minimum growth requirements on a synthetic medium. This may indicate that also in these strains thymidine is a more direct precursor of deoxyribonucleic acid than the other two compounds. The following compounds in concentration 100 μgm./ml. (unless otherwise stated) do not support growth: 5-bromouracil, 5-bromouracil deoxyriboside, 5-aminouracil, 2-thiothymine, 5-ethyluracil (from Dr. G. Elion, Wellcome Research Laboratories), 2-thiouracil, 6-azathymine (from Dr. W. H. Prusoff, Yale University), 5-nitrouracil, alloxan, veronal, barbituric acid, orotic acid, 6-methyl uracil, dihydrothymine,

folic acid (1 μgm./ml.), vitamin B_{12} (50 μgm./ml.), thymidine diphosphate, 1-methyl thymine (from Dr. L. Cavalieri, Sloan-Kettering Institute for Cancer Research), 1-methyl-4-ethoxythymine (from Dr. L. Cavalieri), 2,4 diethoxy-thymine (from Dr. L. Cavalieri) (the last four compounds 10 μgm./ml.). In the presence of 1 μgm./ml. thymine, the above compounds (in concentrations stated) also do not inhibit growth, except for the first five, which inhibit growth for at least 48 hr. when present in the following (or higher) concentrations: 5-bromouracil (10 μgm./ml.); 5-bromouracil deoxyriboside (0·5 μgm./ml.); 5-aminouracil (100 μgm./ml.); 2-thiothymine (100 μgm./ml.); 5-ethyluracil (200 μgm./ml.). Uracil[1] and 2-thiouracil inhibit only at concentrations higher than 200 μgm./ml.

In the presence of 1 μgm./ml. thymidine, 5-bromouracil (100 μgm./ml.) does not inhibit growth; this again may indicate that thymidine is a more direct precursor of deoxyribonucleic acid than thymine. Very strong inhibition of thymine by 5-bromouracil deoxyriboside also points in this direction.

5-Bromouracil (100 μgm./ml.) partially inhibits the growth on nutrient agar. After 48 hr., a secondary growth (papillæ) appears containing mutants having various degrees of resistance to 5-bromouracil. On normal nutrient agar some of these mutant strains appear normal, whereas others form very small colonies.

By growing strain I on a synthetic medium, fortified with 0·02 per cent of 'Proteose Peptone No. 3' (Difco) (suboptimal growth) for more than 48 hr., the back-mutants to complete thymine independence can be isolated. One such back-mutant population consisted of 95 per cent cells inhibited by 10 μgm./ml. thymidine and 5 per cent cells non-inhibited: the latter were isolated and designated strain II (see preceding communication.)

Strain II, which exhibits full growth on a synthetic medium, is not inhibited by 100 μgm./ml. 5-bromouracil, but shows weak inhibition by 500 μgm./ml. of this compound.

Growth inhibition of *Lactobacillus casei* by 5-bromouracil was discovered by Hitchings *et al.*[5]. The inhibition by this compound in strain I can be reversed by increasing the concentration of thymine and is truly competitive against thymine. The mechanism may involve competition for the enzymes, such as the nucleoside-forming enzyme (thymidine phosphorylase[6]); as mentioned above, when thymidine is supplied, the 5-bromouracil indeed does not inhibit. In mammalian tissue, this enzyme synthesizes 5-bromouracil deoxyriboside fully half as readily as thymidine[6]. In our experiments the inhibition index of 5-bromouracil *vs.* thymine in strain I was 2·5 (16 hr.). In strain I both metabolites come from outside; in strain II, thymine is manufactured in the cell; this may explain the two hundred times lower inhibitory effect in strain II.

5-Bromouracil deoxyriboside (if indeed an intermediate) may also be less readily utilized for the synthesis of deoxyribonucleic acid; hence strong inhibition by this nucleoside. The possibility that the deoxyribonucleic acid containing 5-bromouracil participates less readily in the activities of the cell in strain I also cannot be entirely excluded.

More interesting is the finding that the 5-bromouracil can be built into deoxyribonucleic acid also without inhibition of growth. Indeed, strain II on 100 μgm./ml. 5-bromouracil builds in 17–19 per cent (on a cytosine basis) of this unnatural pyrimidine (see preceding communication); yet the speed of cell divisions remains the same as on a medium free from 5-bromouracil.

The above discussion referred to phenotypic changes. In view of the possibility that the deoxyribonucleic acid is a factor in heredity, it was also interesting to study whether such a profound change in its composition, which might have occurred in most, if not all, cells, would be reflected in genotypic changes such as 'mass-mutation'. The thymine-requiring cells (strain I) had indeed entirely different colonies (flat, faint) when grown on a 5-bromouracil medium; however, they returned to normal on a thymine-containing medium free from bromine, in which thymine replaced 5-bromouracil in the deoxyribonucleic acid. The change (inhibition) ought therefore to be classified as merely phenotypic. As mentioned before, the back-mutant colonies (strain II) on a medium containing 100 μgm./ml. 5-bromouracil showed no change whatsoever. This does not preclude the induction of rare mutations by 5-bromouracil; it merely means that, in spite of its being built in rather large amounts into deoxyribonucleic acid, this unnatural pyrimidine does not induce demonstrable mass-mutations.

Thus certain changes are permissible in the deoxyribonucleic acid molecule without demonstrably affecting life of the cell; the changes are reversible; they do not demonstrably change the function of deoxyribonucleic acid as a factor in heredity (if indeed these acids are determinants in inheritance).

Obviously, these findings raise more questions. Do all deoxyribonucleic acid molecules have some of their thymine replaced by 5-bromouracil, or do some of the deoxyribonucleic acid molecules (perhaps genetically inactive) have all their thymine replaced by 5-bromouracil? What is the distribution of 5-bromouracil along the molecule? Can 5-bromouracil be built into deoxyribonucleic acid of other species[7], especially when administered as deoxyriboside? (compare refs. 6,8).

Work is in progress to determine whether unnatural bases can also be built into the deoxyribonucleic acid of unrelated strains of *E. coli* (strain *B* used as host for *T*-phage experiments; American Type Culture Collection No. 9637) and into the deoxyribonucleic acid of *Haemophilus influenzae* having transforming activity; the growth of these micro-organisms was not inhibited even by 1 mgm./ml. 5-bromouracil.

The work presented in both these communications was supported by research grants *E*15 (*C*7) and *C*–1760 (*c*) from the National Institutes of Health, Public Health Service (H. E. Alexander and S. Zamenhof, principal investigators), and by an institutional grant from the American Cancer Society to Columbia University.

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LETTERS TO THE EDITORS

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Nuclear Uptake of Glycine-2-^{14}C in the Newt Embryo

EXPERIMENTS with early amphibian embryos, using glycine-1-^{14}C as a tracer and the autoradiographic technique of Doniach and Pelc[1], have shown that the nuclei take up this substance into high-molecular weight compounds more rapidly than does the cytoplasm[2]. Ficq[3] has also observed a greater activity in the nuclei, using orotic acid-2-^{14}C as well as glycine-1-^{14}C. She points out that, by the neural-tube stage, incorporation has occurred in all tissues which are actively engaged in morphogenesis; and she has shown that the labelled substances were taken up into nucleic acids as well as protein.

In some recent experiments, late blastulæ of *Triturus palmatus* were kept in a solution of glycine-2-^{14}C (1·4 μc./ml.) until they reached the late yolk-plug stage, and early to mid-gastrulæ were kept similarly until the neural-plate stage. They were then fixed in 10 per cent trichloracetic acid, sectioned at 5 μ, coated with Kodak autoradiographic film and exposed for 10–35 days; after development they were lightly stained with Mayer's hæmalum. The autoradiographs of the late yolk-plug embryos show strong incorporation into the nuclei of the mesoderm, both that which had already invaginated to form the archenteron roof and that which still remained on the surface. There was also a somewhat high incorporation into the nuclei of the presumptive neural plate; but in the epidermis and endoderm there is no appreciable difference in activity between the nucleus and cytoplasm. In the neural-plate embryos, heavily charged nuclei are found in the archenteron roof and more lateral mesoderm, and also in the neural plate itself (Fig. 1). Some endoderm nuclei are beginning to be charged at this stage; but there is still no sign of high activity in the epidermis, although this is very obvious at a rather later stage in *Xenopus*[2]. We thus have clear evidence of a high metabolic activity of the nuclei, beginning in the organizer region and spreading to the neural tissue which it induces. Work is proceeding on the characterization of the substances into which the glycine is incorporated.

Fig. 1. Autoradiograph of a neural-plate embryo. (× 60)

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Partial Sex Linkage in the Mouse

THE chromosomes of *Mus musculus* have a high chiasma frequency[1], and for this reason very loose linkages are to be expected. Many of the problems of linkage and independence in this species may therefore have to be solved by cytogenetic methods rather than the breeding techniques of formal genetics.

Among them is the question whether linkage group VII is carried in the pairing segment of the sex chromosome. Partial sex linkage of two group VII mutants, *waved*-2 (*wa*-2) and *shaker*-2 (*sh*-2), was reported in 1947 by Wright[2]. However, there were two unusual features in her results, namely, (*a*) recombination was in excess of 50 per cent, and (*b*) *wa*-2 and *sh*-2 showed the same recombination with sex, though they are not closely linked. As a result, the partial sex linkage interpretation has not been universally accepted. Carter and Phillips[3] repeated Wright's experiment, but failed to find any consistent evidence of sex linkage.

With the object of obtaining evidence on questions such as this we have induced a number of translocations in the mouse, using X-rays, and have identified linkage groups involved in eleven of them. One translocation, *T*8, involves groups I and VII. The linkage with group I was found by backcrossing animals heterozygous for *T*8 and for the group I marker *chinchilla* (c^{ch}) to chromosomally normal $c^{ch}c^{ch}$ homozygotes, and testing their progeny for the semi-sterility which indicates the presence of the translocation. No recombinants were found among forty-seven tested gametes. The *c*-locus was then used for 'tagging' the translocation in further linkage tests, and was found to show close linkage with *wa*-2 and loose linkage with *Rex* (*Re*), also in group VII:

Genotypes of parents	Phenotypes of progeny			
	$\frac{++}{8}$	$\frac{+wa\text{-}2}{0}$	$\frac{cch+}{1}$	$\frac{cchwa\text{-}2}{12}$
$T8++/+cchwa\text{-}2 \times +cchwa\text{-}2/+cchwa\text{-}2$				
	$\frac{+Re}{5}$	$\frac{++}{11}$	$\frac{cchRe}{14}$	$\frac{cch+}{3}$
$T8++/+cchRe \times +cch+/+cch+$				

Translocation *T*8 thus offers a means of settling the question whether linkage group VII is sex-linked. The translocation and the sex bivalent should be cytologically recognizable in primary spermatocytes; it should therefore be possible to establish their chromosomal independence or interdependence.

This work was part of a programme carried out for the Medical Research Council.

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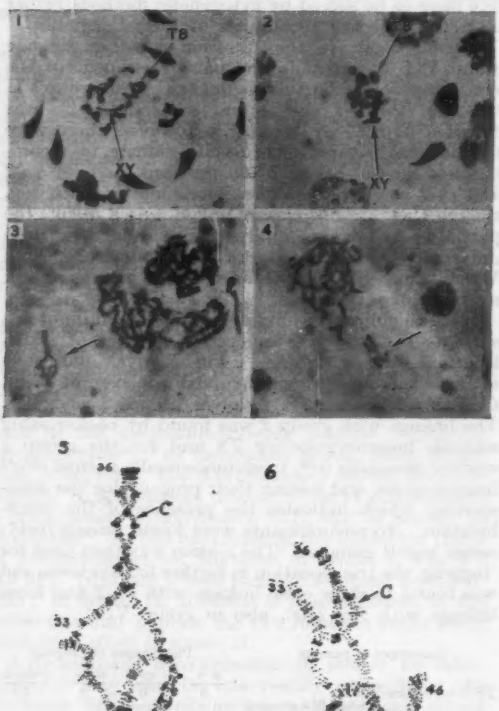
Cytological study of mice heterozygous for the translocation *T*8, mentioned above by Carter, Lyon and Phillips, shows that it does not involve the sex chromosomes. The *XY*-bivalent is clearly recognizable in the accompanying microphotographs of diakinesis and metaphase nuclei of *T*8/+ males and, independent of it, the translocation figure. Analysis of the pachytene figures in the other two photographs has shown that the translocated chromosomes are the medium-sized autosomes numbered 11 and 13 in the preliminary pachytene map of the mouse[1].

It follows that loci in linkage groups I and VII in the house mouse cannot be partially sex linked.



(1) and (2). Diakinesis and metaphase 1 in spermatocytes of *T*8/+ males, showing the independent *XY* bivalent and translocation figure
(3)–(6). Microphotographs and camera lucida drawings of *T*8 in two spermatocyte pachytene nuclei. Autosome 11 is at the upper left part of each figure, autosome 12 lower right; the numbers refer to divisions on the preliminary pachytene map; *C* denotes the centromere

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Placental Transfer of a High Molecular Ferric Carbohydrate

In 1953, I suggested[1] that the placental transfer of iron in the rat is brought about by the placental structures building up a fairly high concentration of some hydrolysable iron compound or compounds, partly or wholly ferritin, the source of which was supposed to be the maternal serum iron. The fœtal needs for the metal were taken to determine the rate at which these intermediate placental iron compounds were mobilized. The iron transfer from the maternal to the fœtal organism thus seemed to be regulated in a manner not very different from that suggested by Granick[2] for the gastro-intestinal absorption of iron. Since Nissim[3] first introduced saccharated colloidal iron for parenteral use, several papers on this subject have appeared. Considering the possibility of an untoward effect upon the fœtus brought about by the colloidal iron preparation, it seemed important to investigate this therapeutic agent, particularly as to permeability of the placenta to it, before recommending its use in the anæmias of pregnancy. In doing so, I have used the material and techniques described in my earlier communication[1], in which measured values in normal untreated pregnancy were given; these values have been used as controls in the present investigation.

1 ml. of 'Ferrigen' (in the United States 'Astrafer'), kindly put at my disposal by Astra Ltd., Södertälje, Sweden) was injected intravenously into the pregnant rat 24 hr. before killing; 'Ferrigen' is a ferric carbohydrate of high molecular weight, the stable solution of which contains 20 mgm. of elemental iron/ml., and has a *p*H of 7·3. 51 pregnant rats were used and divided into five groups, pregnancy being allowed to continue for 15, 17, 19, 20 and 21 days. The iron fractions determined were the same as measured earlier[1], that is, for the fœtal bodies: (1) the total iron of the fœtus, and (2) the iron hydrolysable according to the method used (the latter iron fraction was taken to correspond to the depot iron fraction). In the placental organs the hydrolysable iron fraction only was recorded.

It was found that the maternal rats did not reveal any blood dilution 24 hr. after the injection, the hæmatocrit values being within the normal range ($41{\cdot}0 \pm 0{\cdot}9$). The plasma iron values of the mother rat were high, the mean value being $265 \pm 13{\cdot}1\ \gamma$ per cent. As the iron saturation limit for rat serum has been found to be about 500 γ per cent[4], it was concluded that no loosely bound iron was left in the plasma. The values for the hydrolysable iron fraction of the maternal livers was found to be about four times that measured in normal untreated pregnancy, or $43{\cdot}0 \pm 2{\cdot}9$ mgm. per cent. In all the above-mentioned respects, the maternal animals were identical without significant variations associated with the duration of pregnancy. The total and hydrolysable iron concentrations of the fœtal bodies at different stages of pregnancy are shown in Fig. 1. From the fairly high concentrations of total and

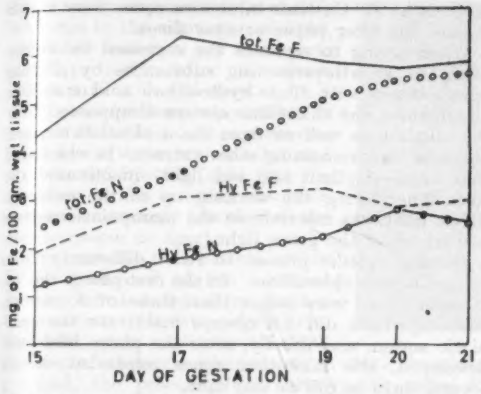

Fig. 1. Total and hydrolysable iron per unit fresh fœtal weight in 'Ferrigen'-treated (*F*) and untreated (*N*) rats during the observed period of pregnancy

hydrolysable iron measured in the fœtal bodies of the rats treated with 'Ferrigen' in the earlier period of gestation, it is clear that some of the iron of the therapeutic agent has passed through the placental barrier. If the preparation had passed freely and unaltered through, we would expect its passage to increase with the duration of pregnancy (see Flexner and Gellhorn[6]). Here, however, the reverse happens. Furthermore, since the iron compound of 'Ferrigen' is very easily hydrolysable, we would expect to find the hydrolysable iron fraction to be proportionally further increased if the preparation had passed the placental barriers unaltered. This did not happen; the hydrolysable iron fraction throughout constitutes some 50 per cent of the total fœtal iron, as was the case in untreated pregnancies. Hence the ferric carbohydrate does not pass through the placental organs unaltered, but is broken down by the maternal organism, giving rise to increased iron depots and serum iron concentration. This is accompanied by an increased synthesis of the intermediate placental iron compound referred to earlier (Fig. 2), from which iron is mobilized by the fœtus according to its need. It is important to note that at no stage of pregnancy do the fœtal bodies of the 'Ferrigen'-treated rats accumulate more iron than is found at term in untreated pregnancies.

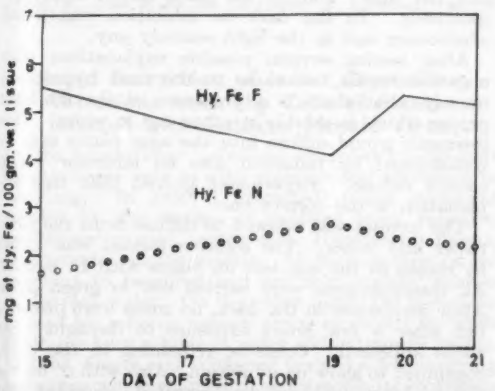

Fig. 2. Hydrolysable iron content per unit fresh weight of the total placental organ during the observed period of 'Ferrigen'-treated (*F*) and untreated (*N*) pregnancies

The features of placental iron transfer suggested here are further supported by the finding that in the 'Ferrigen'-treated rats the period of greatest iron transfer to the fœtus coincides with the lowest iron concentration measured in the placental structures.

A detailed report of these investigations will appear elsewhere.

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Effect of Cervical Sympathectomy on the Onset of Œstrus in Ferrets

THE view that the hypothalamus controls the functions of the pars distalis of the pituitary by way of a chemotransmitter transported through the pituitary portal vessels does not accord with the fact that female ferrets, when exposed to added light, will come into heat during the winter months, whether or not there is a direct vascular link between the pituitary and the hypothalamus[1]. Attention has therefore been turned again to the possibility that peripheral nervous pathways may be concerned in the response.

Bilateral superior sympathetic ganglionectomy was performed on sixteen female ferrets during the autumn of 1953. Seven of these animals were exposed to evening illumination (4.30–10.30 p.m. daily) beginning October 30, 1953. The remaining animals were kept under ordinary laboratory conditions. Sham operations were performed on four animals, all of which were exposed to extra light. Fourteen normal female ferrets were housed as control animals with the group of seven operated animals receiving added light, and nineteen normal female ferrets were kept as normal control animals for the nine operated animals in the non-illuminated group.

By January 22, 1954, the eighteen non-ganglionectomized ferrets which were exposed to added light were in full œstrus. At this time no sign of œstrus was apparent in any one of the seven ganglionectomized animals kept in the same room. These animals were still anœstrous in the middle of June 1954.

Normal spring œstrus had begun by early April in all the nineteen normal control animals kept under ordinary laboratory conditions. At the time of writing, all but two of the nine ganglionectomized animals kept under the same conditions were still anœstrous.

The results suggest that the cervical sympathetic chains are in some way concerned in the mechanism whereby the exposure of ferrets to light accelerates the onset of œstrus.

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Injurious Effect of Air-saturated Water on Certain Invertebrates

It is generally accepted by zoologists as a law of Nature that aquatic animals benefit by as much dissolved air as they can get. Consequently, after a catch is brought home from pond or shore the water is if possible aerated. Yet it is known, especially from the classical work of Juday[1], that whereas the oxygen content of the deep water of certain lakes falls very low and remains so for several months in summer, there is an active invertebrate fauna in and above the mud. It has never been suspected, however, that dissolved oxygen at atmospheric partial pressure, that is, in fully aerated water, might actually be harmful to certain mud dwellers in pond and sea; yet we have found this to be so.

Experiments have now been made in which the survival-time was compared, in water at two different degrees of aeration, of aquatic invertebrates that live in or near the surface of mud. In each experiment, through one sample of water, containing animals, air was bubbled continuously for several weeks, and through another a mixture of one part of oxygen to twenty-four parts of nitrogen, giving water approximately one-fifth aerated. The following animals survived longer in the less well-aerated water: the larvæ of *Chironomus* and of *Anatopynia* (another chironomid midge), *Heterocypris* (an ostracod), young *Tubifex* and young *Scoloplos* (a polychæte worm). The following animals lived equally well in one-fifth aerated and in fully aerated water: *Herpetocypris* (another ostracod), adult *Tubifex*, young *Arenicola*, adult *Planorbis*, *Physa* (another pond snail), *Pisidium* and *Phaenocora* (a rhabdocœle worm). The only animals which survived longer in fully aerated than in poorly aerated water were *Sabella*, young *Planorbis* and young *Limnaea*.

Not only did a number of species survive longer in poorly than in well-aerated water, but *Chironomus* larvæ, young *Tubifex* and young *Scoloplos* grew bigger in the poorly aerated water. In addition, although fewer young *Planorbis* survived in poorly aerated water, nevertheless they grew bigger in it, and *Phaenocora*, which survived equally well in well-aerated and poorly aerated water, grew bigger in the latter.

A full account of this work, in which specific names will be given, is to be published in the *Proceedings of the Royal Society*.

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Chlorophyllide, the Probable Precursor of a Growth Inhibitor

When investigating the production of growth substances by *Chlorella vulgaris* var. *viridis*, difficulties were met which were ascribed to a growth-inhibiting substance, possibly Pratt's 'chlorelline'[1]. *Staphylococcus aureus* proved to be a suitable test object for the growth inhibition. Small pieces of filter paper or agar slices containing concentrated and dried crude ether extracts of *Chlorella* were placed on agar plates seeded with bacteria. After 2–5 hr. of diffusion of the extract, and incubation of the bacteria at 37° C., clear inhibition zones were visible around the filter paper or agar slices.

When trying to separate the supposed chlorelline from the growth-promoting substances by shaking ether extracts with dilute hydrochloric acid or sodium bicarbonate, the chlorelline always disappeared from the alkaline as well as from the acid solutions, and also from any remaining ether extract. It was found that light—daylight and red light—inactivated the chlorelline during the working up of the extracts. Green light was inactive, so the manipulations were carried on in dim green light.

Bacillus subtilis proved to react differently from *S. aureus* with chlorelline. In the first place, the inhibition zones were larger than those of *S. aureus*. Secondly, light did not always inactivate the antibiotic action, and thirdly, after the plates had been developed, the inhibition zones expanded during several days in diffuse daylight.

This suggested that chlorelline consists of more than one component. The spectral activity indicating some relation with the chlorophylls, a mixture of benzene, petroleum ether and acetone (10 : 2·5 : 2), was used as a solvent for the separation of the components by paper chromatography. The ether extract was spotted on a paper strip (Whatman No. 4, buffered at *p*H 6, stored above sulphuric acid) and the ascending method was used. After drying, the paper strips were tested on agar plates seeded with bacteria. The plates received dim light in the incubator. *S. aureus* showed one zone of inhibition ($R_F = 0$) around the spot of the chlorophyllides on the strip; *B. subtilis* showed three zones of inhibition: (*a*) $R_F = 0$, expanding after development; (*b*) $R_F = 0{\cdot}60$, just below the xanthophyll; (*c*) $R_F = 0{\cdot}95$ at the same spot as the carotene.

Being mainly interested in the zone with $R_F = 0$, because of its expansion, we stopped the investigation of the two other inhibitors, which are only active on *B. subtilis*, for the time being.

We first examined the later expansion of the inhibition zone with *B. subtilis*, and found that this is due to the fact that *B. subtilis* can contract in spore form; *S. aureus* cannot do this.

When testing whether light is responsible for the expansion on the *B. subtilis* plates, we obtained varied results. Plates of *B. subtilis* and of *S. aureus* supplied with dried ether extracts on filter paper were incubated immediately in the light (daylight and red light) and in the dark (green light) respectively. In the dark no inhibition was found whatsoever and in the light scarcely any.

After testing several possible explanations with negative results, we came to the next hypothesis, namely, that there is a precursor of the inhibitor proper which is soluble in ether and in water. This precursor would diffuse into the agar plates and be transformed by radiation into an inhibitor which cannot diffuse. Experiment proved that this explanation is the correct one.

The extract was allowed to diffuse from the filter paper into water. The solution formed was tested by means of the cup test on plates with *B. subtilis*. All manipulations were carried out in green light. After incubation in the dark, no zones were present; but after a few hours exposure to daylight clear zones appeared. Controls, remaining in the dark, continued to show no inhibition. Also with *S. aureus* the inhibitor could be demonstrated, provided that the plates were illuminated only after the diffusion of the precursor had taken place. The zones produced

in our early experiments evidently were due to the admission of light, which we had not yet learned to avoid properly, after a certain diffusion time in the dark.

We consider these experiments as a proof that the inactive precursor is soluble in water and in ether and is converted by (red) light into the inhibitor, which is either insoluble in water or strongly adsorbed to the carrier (paper or agar).

The evidence that chlorophyllide is the precursor of the inhibitor is corroborated by four further observations: (1) extracts of *Chlorella* cells, grass and kale all show the same inhibition phenomena; when chromatographed, the precursor had always the same R_F value as the chlorophyllide, which is formed during the extraction while the extract is in contact with the extracted cells, that is, in the presence of chlorophyllase; (2) the inhibitor always appears exactly on the same spot as the chlorophyllides, when chromatographed with water, ether, acetone, ethyl-acetate, a mixture of benzene, petroleum ether and acetone, butanol–water, butanol–water–ammonia, butanol–water–acetic acid, *iso*propanol–water–acetic acid, *iso*butanol–water; (3) the inhibitor is produced only from extracts kept in contact with the cells or tissue and which contain chlorophyllide; we were unable to find it in fresh extracts, extracts from boiled tissue and extracts kept apart from the cells or tissue, all of them containing chlorophyll-*a* and -*b*, but no, or scarcely any, chlorophyllide; (4) when the inhibition has become apparent after illumination, the chlorophyllide has bleached.

A detailed account of the experiments will be published elsewhere.

Investigations are in progress on the interaction of chlorophyllide and light on the cell division of *Chlorella* and of other green plants, especially in view of the many phenomena controlled by light, particularly by the longer wave-lengths, probably through inhibition of cell division (photoperiodicity, leaf abscission, dormancy of seeds, etiolation, etc.).

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Rapid Extraction of Intact Crystalline Inclusions from the Cells of Plants infected with Tobacco Mosaic Virus

The intracellular inclusions produced by different plant viruses vary in their stability and resistance to handling. In 1950, I extracted[1] intact inclusions formed by the viruses of cabbage black ringspot, cauliflower mosaic, severe etch, *Hyoscyamus* mosaic and tomato aucuba mosaic. All these inclusions are resistant to handling and are only slightly soluble in distilled water. On the other hand, the inclusions formed by tobacco mosaic virus, as shown by Sheffield[2], are very soluble in water and extremely fragile. In 1953, Steere and Williams[3] devised a freeze-drying technique which enabled these intracellular inclusions to be removed from the cell intact and photographed in the electron microscope.

Since the effect of freeze-drying is probably only a fixation of the nucleoproteins, a much more simple and rapid method has been devised. This consists in removing strips of epidermis, containing crystalline inclusions, from the leaves of mosaic-infected tobacco plants, and immersing them for 3–4 min. in Carnoy's fluid. They should then be rinsed in 96 per cent alcohol and placed in distilled water. The intact crystals can then easily be removed by means of two fine needles, and mounted for electron microscopy. If necessary, the inclusions can be preserved in 96 per cent alcohol for a year or more.

Figs. 1 and 2 are electron micrographs of two crystalline inclusions of tobacco mosaic virus obtained by this method. They show clearly the arrangement of the virus particles.

Acknowledgments are due to Mr. J. D. Bakker for taking the electron micrographs and to Prof. Van Slogteren, director of the Laboratorium voor Bloembollenonderzoek, Lisse, Holland, where this work was carried out.

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A New Type of Branching in Liverworts

Recently, we began a study of the morphogenetic effect of various factors on the gemmæ of *Marchantia polymorpha* and *Lunularia cruciata*. These structures offer excellent material for such studies, since they are readily obtainable in quantity at all seasons of the year, are large enough to be handled readily, but small enough to be economical of space and require no special equipment for their study beyond some Petri dishes and a dissecting microscope. We have found that they are sensitive to treatments of many kinds; but for some reason they seem to have been overlooked, for we have been able to find only one paper on experimentation with them—that of Nagai[1], who plasmolysed them with rather interesting results.

At the very beginning of our studies, we found that gemmæ treated in a number of different ways responded by branching in a most unusual manner. Ordinarily, thalli of *Marchantia*, *Lunularia* and other thallus liverworts spread out in a fan-like shape and become continually wider by the extension of thallus tips and the formation of new apical cells from time to time. The new type of branching took

place at right angles to the usual direction of branching. This resulted in the formation of two lobes at the tip of the thallus, with one above the other so as to produce a 'double-decker' effect.

Gemmæ which had been treated with various concentrations of a number of substances were grown on a klinostat; it was found that the direction of branching had no relation to the direction of the pull of gravitation, but always took place in a plane parallel to that of the flat surface of the thallus, regardless of the orientation of that structure.

The peculiar type of branching has been produced by all the following substances: acenaphthene, actidione, caffeine, colchicine, chromic acid, naphthalene, parathion, picric acid and sodium cacodylate.

The preceding represents a most diverse and miscellaneous group of chemicals, which have little in common save that five of them are known polyploidizing agents. Thus far, of chemicals tested, surprisingly few have failed to induce the new type of branching. Plant growth hormones—indole acetic acid, indole butyric acid, maleic hydrazide, diphenylamine, ether, benzoguanimine, and dichlorophenoxyacetic acid (2-4-D) have not produced branching.

Irradiation with ultra-violet light produces the new type of branching, and cobalt irradiation has a like effect.

Branching of this type appears to be transitory. Usually, the lower lobe of a pair secures dominance over the upper and grows out rapidly, leaving the upper lobe as a mere ridge or at most a ligule-like appendage. Very rarely, the upper lobe becomes the dominant one and the lower one is then suppressed. In gemmæ grown on the klinostat, both upper and lower lobes may grow for two or three weeks. However, after that length of time, and while still on the klinostat, the lower lobe usually becomes dominant, and the two, formerly independent, lobes grow together in some way not yet understood.

In spite of the results secured with several substances which are known often to cause polyploidy, it is not thought that this branching is due to polyploidy, nor does it appear that any of these effects are permanent. Chromosome counts will be made to find out whether or not polyploidy plays a part in the process. It is proposed also to make studies on the mechanism of this type of branching.

It is notable that branching of this type has never been reported in Nature and has never been found in any growths of *Lunularia* and *Marchantia* observed by either of us in greenhouses or in the open. It has, however, appeared two or three times in control cultures of *Lunularia* grown on filter paper in Petri dishes. A somewhat similar type of bifurcation has been produced by Labouriau[2], by the application of growth hormones to the leaves of the fern, *Anemia collina raddi*.

Details of studies on the new type of branching and of other morphogenetic effects of various factors on liverwort gemmæ will be published elsewhere.

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Amino-Acid Content of Plants

With the object of correlating existing information and the possibility of establishing a relationship with taxonomy, we have examined, both qualitatively and quantitatively, the free and combined amino-acid content of the cell juices of a number of plants widely distributed throughout the vegetable kingdom, using a carefully worked-out paper chromatographic method. A complete account of the work will be published in due course; but in view of recent publications[1] on the use of paper chromatography in the study of various aspects of the distribution and metabolism of amino-acids in plants, it appears to be desirable to place on record the results we have obtained during the past few years.

Table 1 gives the percentages of the total (Kjeldahl) nitrogen present in that portion of the total solids of the plant juice soluble in 75 per cent ethyl alcohol as each of the amino-acids listed, and Table 2 the corresponding figures for the amino-acids found in hydrolysates of the insoluble residues after alcohol extraction. The amino-acids found in *Malus sylvestris* agree with those qualitatively identified by Hulme and Arthington[3]. *Funaria hygrometrica*, *Mucor mucedo*,

Table 1. Amino-Acids and Amides Present in 75 per cent Alcohol Extracts

Acid	*Beta vulgaris*	*Malus sylvestris*	*Funaria hygrometrica*	*Pinus sylvestris*	*Mucor mucedo*	*Equisetum arvense*
Alanine	5·3	1·7	1·7	5·4	1·8	5·8
β-Alanine	8·3	1·2	—	2·8	—	—
Arginine	3·5	9·2	9·4	9·4	4·8	9·6
Asparagine	7·6	12·2	1·4	2·4	9·5	10·2
Aspartic acid	4·5	7·4	15·4	2·7	22·8	7·4
γ-Amino butyric acid	8·0	9·8	5·3	5·3	6·8	3·5
Citrulline	—	—	6·3	—	—	—
Cystine	0·8	—	2·2	—	—	—
Glutamine	26·2	24·8	2·3	5·3	15·2	15·4
Glutamic acid	6·0	8·9	22·4	43·2	11·6	8·2
Glycine	2·0	1·2	0·5	2·4	1·9	2·5
Histidine	3·0	—	—	—	—	—
iso-Leucine	1·0	2·6	1·2	1·9	1·9	2·9
Leucine	3·4	8·4	10·4	1·7	2·4	7·8
Lysine	2·2	0·8	7·2	1·4	3·7	4·5
Methionine	—	—	—	1·3	0·6	0·9
Proline	—	1·3	—	—	1·4	—
Phenylalanine	2·0	1·4	0·6	—	0·9	0·9
Serine	4·0	0·9	0·6	0·7	2·4	2·5
Threonine	3·6	1·0	0·8	1·6	1·1	4·1
Tyrosine	2·0	0·9	2·4	0·9	1·2	0·9
Valine	2·3	2·4	2·4	4·9	2·9	6·2
Total	95·7	96·1	92·5	93·3	92·9	93·3

Table 2. Amino-Acids Present in Hydrolysates of Alcohol-Insoluble Fractions

Acid	*Beta vulgaris*	*Malus sylvestris*	*Funaria hygrometrica*	*Pinus sylvestris*	*Mucor mucedo*	*Equisetum arvense*
Alanine	6·8	3·6	6·8	8·6	6·7	4·3
Arginine	14·3	15·8	13·2	15·7	12·2	19·5
Aspartic acid	9·0	10·2	7·8	10·2	16·4	8·2
Cystine	1·1	1·0	1·5	1·2	2·2	—
Glutamic acid	21·2	19·2	18·8	29·2	35·2	14·5
Glycine	4·7	3·8	6·5	3·6	3·8	6·5
Histidine	2·0	2·1	—	4·1	1·6	4·2
Hydroxy-proline	—	1·0	—	0·9	—	—
iso-Leucine	2·2	4·1	2·2	6·1	0·7	4·3
Leucine	10·8	18·9	11·3	14·2	5·2	9·6
Lysine	2·5	2·2	8·4	2·2	3·8	11·2
Methionine	2·5	2·1	0·9	1·2	1·1	1·4
Proline	4·5	3·4	4·2	1·7	4·2	5·1
Phenylalanine	3·1	2·4	5·6	2·4	1·0	4·2
Serine	4·5	3·0	3·4	0·6	3·3	2·8
Threonine	4·0	2·3	4·4	0·6	2·2	3·7
Tryptophan	3·2	2·5	—	2·5	—	—
Tyrosine	2·8	2·1	3·9	2·1	2·1	3·7
Valine	6·2	6·0	7·2	1·9	4·4	2·3
Total	105·4	105·7	106·1	104·0	106·1	105·5

Pinus sylvestris and *Equisetum arvense* were chosen as well-known examples of the Bryophyta, Thallophyta, Gymnospermae and Pteridophyta respectively. We have also obtained qualitative results on *Lolium italicum* which agree closely with those of Synge[3] on *L. perenne*, and on *Medico sativa* agreeing with those of Vickerey[4], who used standard chemical methods of analysis.

E. arvense has also been examined at regular intervals throughout the development of the sporophyte generation.

Work on these and related lines is being actively pursued.

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Occurrence of *Falkenbergia rufolanosa* in the Isle of Man

Since the reports by de Valera[1], Harvey and Drew[2], and Drew[3] of the occurrence of *Asparagopsis armata* Harv. and what is believed to be another phase of its life-history, *Falkenbergia rufolanosa* in a number of localities in Ireland and on the south-west coast of England, its spread around the British coast has been watched with interest by phycologists. A spread eastwards along the south coast was reported by Kerslake[4] in September 1953 when *Asparagopsis armata* was found on Wembury Beach.

During the course of a survey of an area in and around the harbour at Port St. Mary, Isle of Man, by a party of students from the University of Liverpool and Royal Holloway College, London, at the end of March, *Falkenbergia rufolanosa* was found in great quantity floating in the water in the harbour at low tide, and both floating and attached to other seaweeds in pools in various positions on the shore. This is the first record for the plant in the Isle of Man, and it is of interest that it should appear in abundance, first of all, in one of the functioning harbours and one used by coastal vessels. A search of the shores near by indicated that it had, as yet, spread very little from the harbour, though the spread had obviously begun; it was found growing attached in a few pools on the outer side of the breakwater, and one can perhaps assume that its spread around the Island is only a matter of time. Of all the material examined, none was found to be reproducing.

It will be of interest to see whether the invasion of the Isle of Man by *Falkenbergia* is followed, as it has been in other places, by *Asparagopsis armata*.

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Use of Glutamine by the Mammary Gland for the Synthesis of Casein

In continuation of earlier work on casein synthesis[1], further experiments have aimed at determining which components, taken from the blood-stream by the mammary gland, provide the glutamic acid of casein.

1-^{14}C DL-glutamine was injected intravenously into a lactating goat and specific activities were measured in various components of blood and milk taken at intervals up to 12 hr. after injection. During the first few hours the specific activity of the free glutamine of plasma remained many times that of both the free glutamic acid and the glutamic acid of plasma proteins. This difference is illustrated (Table 1) by the specific activities in blood taken at 3 hr. after injection; in samples taken at 20 min. and 1 hr. the specific activities of glutamine were higher than at 3 hr. while those of free glutamic acid and plasma protein glutamic acid were approximately the same or lower.

Table 1. Specific Activities in Blood and Milk Samples taken at 3 hr. after injecting 1-^{14}C DL-glutamine (425 mgm.: 38·0 μc.) (μc./m.mol. carbon in carbon No. 1)

Blood plasma		Milk	
Free glutamine	117×10^{-5}	Casein glutamine (*a*)	143×10^{-5}
Free glutamic acid	$27{\cdot}2 \times 10^{-5}$	Casein glutamic acid (*a*)	$< 25 \times 10^{-5}$
Plasma protein glutamic acid	$1{\cdot}73 \times 10^{-5}$	Total glutamic acid of casein (*b*)	122×10^{-5}

(*a*) After enzymatic hydrolysis. (*b*) After acid hydrolysis.

Casein samples were hydrolysed in two ways: by heating with hydrochloric acid and by incubating with a pancreas suspension. The specific activity of glutamic acid in each acid hydrolysate was measured, and glutamine and glutamic acid were isolated from each pancreas hydrolysate and their specific activities also measured. The first milk sample was taken at 1·5 hr.; the specific activities found in the casein of the second milk sample taken at 3 hr. are shown in Table 1. It is seen that the specific activity of casein glutamine is slightly higher than that of the free glutamine of plasma at 3 hr., while that of casein glutamic acid is much lower. The results suggest that those residues which are present in casein as glutamine are derived largely from the free glutamine of plasma, and those present as glutamic acid are derived from some other source.

To confirm that the free glutamine of plasma is directly incorporated into casein, (1-^{14}C : amide-^{15}N) DL-glutamine was injected intravenously into the goat and milk taken at 1·5 hr. after injection. It is seen in Table 2 that, as expected, the ratio (μc/m.mol. carbon : atoms per cent excess ^{15}N) in the glutamine

Table 2. (1-^{14}C : Amide-^{15}N) DL-Glutamine (563 mgm.) injected and Milk taken 1·5 hr. later

	Atoms % excess ^{15}N	μc./m.mol. carbon in carbon No. 1	μc./m.mol. carbon / Atoms % excess ^{15}N
Injected glutamine	25·8	$1{,}800 \times 10^{-5}$	$69{\cdot}8 \times 10^{-5}$
Casein glutamine	0·611	$30{\cdot}6 \times 10^{-5}$	$50{\cdot}1 \times 10^{-5}$
Amide N of casein (*a*)	0·444	—	—
Non-amide N of casein (*b*)	0·004	—	—

(*a*) Nitrogen released as ammonia on acid hydrolysis. (*b*) Nitrogen not released as ammonia on acid hydrolysis.

of casein was approximately the same as in the injected glutamine.

It has been postulated that γ-glutamyl peptides formed from glutamine by enzymatic exchange reactions are important intermediates in protein synthesis[2]. The present results suggest that the glutamine which is incorporated into casein does not exchange or lose its amide nitrogen in the process, and therefore apparently does not pass through intermediate γ-glutamyl peptides.

Techniques which differed from those used in previous work on casein synthesis[1] were as follows. 1-^{14}C DL-glutamine was synthesized from 1-^{14}C DL-glutamic acid by the method of King and Kidd[3]; amide-^{15}N DL-glutamine was synthesized from DL-glutamic acid and ^{15}N ammonia by a slight modification of the same method. The pancreas suspension contained 25 gm. of fat-free and minced pig pancreas/100 ml. 25 per cent ethanol; before use it was incubated and then dialysed to remove amino-acids. Glutamine and glutamic acid were isolated from blood plasma, and protein hydrolysates, by chromatography on 'Dowex-50' resin. Specific activities of carbon No. 1 of glutamine and glutamic acid were measured after decarboxylation with glutamic decarboxylase. The amide nitrogen was obtained from glutamine for ^{15}N analysis by converting to pyrrolidone carboxylic acid and ammonia.

I am indebted to Dr. D. D. Woods for providing the glutamic decarboxylase and pancreas suspension, and to Dr. D. H. Tomlin for making the determinations of nitrogen-15.

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A Case of *Shigella sonnei* Septicæmia in a Calf

During the course of routine laboratory examinations performed on a long bone from a two months-old calf, which died without symptoms the previous day, we isolated in pure culture from the bone-marrow a strain of a Gram-negative, non-motile, non-spore-forming organism.

At the time of the isolation, it exhibited the following characteristics:

Glucose	acidified without gas in 24 hr.
Lactose	acidified without gas in ten days
Saccharose	acidified without gas in eight days
Mannitol	acidified without gas in 24 hr.
Rhamnose	acidified without gas in four days
Salicin	no fermentation recorded in thirty days
Xylose	no fermentation recorded in thirty days
Methyl red reaction	positive
Voges–Proskauer reaction	negative
Indole	no production recorded
Hydrogen sulphide	no production recorded
Urease	no production recorded
Sodium citrate	no growth recorded
IMViC formula is thus	− + − −

As these were the characters of *Shigella sonnei*, the agglutination with an antiserum was performed and confirmed the identification.

This is the first case, so far as we know, of a human *Shigella* occurring in an animal, either as an intestinal infection or as a septicæmia. The finding of *Sh. sonnei* in the medulla is not extraordinary, since it has already been described in human beings[1]. The importance of our finding is still to be assessed, especially for its repercussion in meat hygiene.

We are indebted to Dr. R. Buttiaux for confirmation of our diagnosis. Full details of our investigations will be published elsewhere.

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Identification of Certain 'Ketosteroids' from Cattle Urine as Ionone Derivatives

In recent years, our knowledge of 17-ketosteroid excretion and metabolism in the human being has greatly increased. However, in the little research work in this field which has been devoted to cattle, great uncertainty has always prevailed regarding the nature of the compounds measured by the Zimmermann or Pincus reaction. All investigators are agreed that the steroids from cattle urine could in no case be identical with the 17-ketosteroids from human urine[1].

A short time ago we succeeded in identifying several of these compounds as ionone derivatives, which Prelog and his co-workers isolated from pregnant mares' urine[2]. The presence in cattle urine of these substances had been surmised by Klyne (personal communication). One of the two main fractions, which we obtained by chromatography of the neutral ketonic lipid fraction from cattle urine, without regard as to whether it was urine from bull, cow or ox, proved to contain (2,3,6-trimethyl-benzal)-acetone (Prelog's ketone *J*) among other, as yet unidentified, compounds. The other main fraction consisted almost entirely of 5-hydroxy-*cis*-tetrahydro-ionone (Prelog's hydroxyketone *G*) and a smaller fraction, which follows the second main fraction, consisted of this compound and 5-oxo-*cis*-tetrahydro-ionol (Prelog's hydroxyketone *E*). The presence in cattle urine of other ionone derivatives which have been isolated from mares' urine, such as 5-oxo-*cis*-tetrahydro-ionone (Prelog's diketone *D*), 2,2,8-trimethyl-bicyclo-[0,0,4]-dekadien-5,7-one-4 (Prelog's ketone *K*) and a bicyclic hydroxyketone of not fully established structure (Prelog's hydroxyketone *C*), is not excluded, but as yet not definitely proved.

It is very remarkable that all these substances react in the Zimmermann test. The absorption spectra of several of the coloured compounds are identical with those of cattle urine extract: an absorption curve which falls continuously from shorter to longer wave-lengths with a more or less pronounced plateau at about 500 mμ. One of the compounds (ketone *J*) even gives a pure violet Zimmermann colour which is similar to that of 17-ketosteroids. It shows a distinct absorption maximum at 530 mμ and low absorption at shorter wave-lengths.

With the Pincus reagent the hydroxyketone *G* gives a blue-violet colour with an absorption maximum at 550 mμ, identical with the colour given by the second main fraction from cattle urine extract. In some

cases this absorption maximum appears in the Pincus colour of the total ketonic fraction. This maximum has also been described previously by Meschaks and by Mixner and Saunders.

Among these ionone derivatives, which form by far the greater part of the compounds determined by the usual ketosteroid reactions, a few 17-ketosteroids occurred in minute quantities. Three of these could be identified with more or less certainty as dehydro-*epi*-androsterone, etiocholanolone and 11-hydroxyandrosterone. In any event, the large amounts of the testosterone metabolites androsterone and etiocholanolone, which are excreted in human urine, were shown to be absent in cattle urine. This is most peculiar, as testosterone is believed to occur in the cattle organism. It was isolated for the first time from bulls' testes by Laqueur in 1935. These findings, however, are in accordance with the very low content of androgens in bulls' urine.

As to the origin of these ionone compounds, it is very likely that they are derived from carotenoids (Prelog *et al.*). Bearing in mind the fact that the ionone derivative 5-hydroxy-*cis*-tetrahydro-ionol, which Prelog and his co-workers isolated from pregnant mares' urine (diol *A*), has also been found in bulls' and pregnant cows' urine by Broadbent, Brooks and Klyne[3], and that horses and cattle mainly feed on the same carotene-rich material, it is not surprising that the same carotenoid derivatives should occur in the urine of both kinds of animals. It seems very probable, therefore, that these compounds will occur also in the urine of other animals whose food is rich in carotenoids, and that they will interfere there with ketosteroid determinations. We found in a preliminary investigation that they are absent from dogs' urine.

Full details of this work, which is still in progress, will be published elsewhere.

We are much obliged to Prof. V. Prelog and his co-workers, Dr. B. G. Engel and Dr. J. Würsch (Zurich), who supplied us with samples of the ionone compounds for identification purposes. Thanks are also due to Dr. W. Klyne (London) for valuable information.

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Effect of Œstrogen and of Vitamin A on Vaginal Cornification in Tissue Culture

Recent interest in the rodent vaginal epithelium as a target organ for studying the interaction of dietary and endocrine factors[1] has led to an investigation of the post-fœtal vaginal epithelium of the rat in tissue culture. Whereas Emmens and Ludford[2] were unsuccessful in a similar attempt, quite recently Hardy, Biggers and Claringbold[3] were able to culture the mouse vaginal epithelium by the hanging-drop method and demonstrated the sensitivity of this tissue to œstrogenic substances.

In the present investigation, 99 explants of the vaginal epithelium of eleven prepuberal rats (3–4 weeks old) have been successfully grown for one to nine days in watch glass cultures[4,5], and keratinization has been produced precociously by means of œstrone (0·13 mgm./100 ml. media) added to the nutritive medium. It was found, however, that the control vaginal epithelium cultivated in a standard medium also underwent keratinization, although not as rapidly as that treated with the folliculoid.

Before cultivation the vaginal epithelium is in the typical prepuberal state. After only one or two days on the œstrogenized culture medium, the epithelium becomes stratified, squamous and highly keratinized, although not hyperplastic. Up to the second day, the control groups appear much like the tissue before cultivation; but during the third or fourth day the cells beneath the original cuboidal epithelium become squamous, and by the fourth or fifth day have formed a typical stratified squamous epithelium and keratin. On continued cultivation, the epithelium becomes highly cornified and is histologically indistinguishable from that treated with œstrone. Careful examination of the control photograph presented by Hardy *et al.*[3] shows the beginning of a stratified squamous epithelium beneath the superficial cuboidal cells in their 96-hr. culture of mouse vagina; in our experiments with rat tissue the cuboidal cells are afterwards sloughed.

These results confirm the observations of Hardy *et al.*[3] that œstrogens have a direct action on the rodent vaginal epithelium *in vitro*, but the local response to a steroid under the simplified conditions of organ culture may not be evoked in the same way as a systemically distributed steroid *in vivo*. These *in vitro* results, therefore, do not exclude the possibility of metabolic 'activation' as suggested by Szego and Roberts[6].

The tendency for the control groups to undergo keratinization may be due to a lack of available vitamin A. Recent experiments have shown that synthetic vitamin A added to the control culture medium not only suppresses keratinization but also induces the production of a mucus-secreting epithelium (cf. Fell and Mellanby's observations[5] on chick ectoderm *in vitro*). On the other hand, a concentration of vitamin A which inhibits keratinization in normal medium does not prevent but only delays cornification in the presence of œstrogen. A detailed report of this work will be published in the near future.

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Local Anæsthetic Potency and Penetration of Monomolecular Layers of Nerve Lipoids

In an attempt to find the site of action of local anæsthetics in peripheral nerves, we have endeavoured to discover whether a correlation exists between the anæsthetic potency of some local anæsthetics and their penetration of a monomolecular layer of nerve lipoids.

The anæsthetic potency was estimated as the minimum anæsthetic concentration, that is, the minimum concentration which produces anæsthesia when distribution equilibrium of the anæsthetic agent between its solution and the nerve tissue has been attained. It was determined on isolated desheathed sciatic nerves from frogs (*Rana esculenta*). The local anæsthetics investigated are all tertiary amines which in aqueous solutions will be partly dissociated. The anæsthetic potency of these local anæsthetics depends on the *p*H of the anæsthetic solution; it was determined at *p*H 7·0. Butyl alcohol was taken as a representative of an undissociated aliphatic anæsthetic.

The nerve lipoids used for the monolayer were extracted from frogs' sciatic nerves. The monolayer was spread on a Ringer solution which contained 0·01 *M* sodium phosphate, *p*H 7·0, and the area of the monolayer was adjusted to a pressure of 10 dynes/cm. This area was kept constant during the experiment. Varying concentrations of the local anæsthetics were injected in the Ringer solution below the monolayer, and after careful stirring, the increase in pressure against the Ringer solution was measured (Fig. 1).

Table 1 shows the increase in pressure produced by the minimum anæsthetic concentration of the five local anæsthetics and of butyl alcohol. In addition is shown the number of molecules which penetrate per cm.² of the monolayer at the minimum anæsthetic concentration. These numbers were calculated by means of Gibbs's adsorption equation.

Table 1. Minimum Anæsthetic Concentration, Increase in Pressure in the Monolayer, and Number of Molecules Penetrating the Monolayer, *p*H 7·0

In columns 3, 5 and 7, procaine is set equal to 1

Anæsthetic	Minimum anæsthetic concentration (m*M*/l.)	Relative anæsthetic potency	Increase in pressure in monolayer (dyne/cm.)	Relative increase in pressure	Concentration in monolayer (mol./cm.² × 10^{12})	Relative concentration
Procaine	4·6	1	7·0	1	8·9	1
Cocaine	2·6	1·8	9·0	1·3	10·0	1·1
Tropacocaine	2·2	2·1	9·4	1·3	9·7	1·1
Tetracaine	0·01	460	2·5	0·4	3·8	0·4
Nupercaine	0·005	920	3·7	0·5	5·4	0·6
Butyl alcohol	68	0·07	9·8	1·4	14·7	1·7

The order of the ability of the six anæsthetics to penetrate the monolayer followed that of their anæsthetic potencies; but the increase in pressure in the monolayer produced by the minimum anæsthetic concentration of the six anæsthetics differed (Table 1, col. 4), and the numbers of molecules penetrating per cm.² were also different (col. 6). However, in view of the large differences between the minimum anæsthetic concentrations (1 : 920, or if butyl alcohol is included, 1 : 13,500), the differences in the results from the monolayer are so small that there seems to be a correlation between the anæsthetic potency and the penetration of a monolayer of nerve lipoids.

A more detailed report of this work will appear in *Acta Pharmacologica et Toxicologica*.

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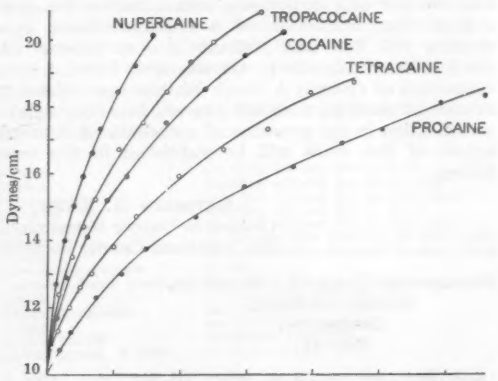

Fig. 1. Increase in pressure in a monolayer of nerve lipoids plotted against the concentration of the local anæsthetics in the Ringer phosphate buffer, *p*H 7·0. The upper row on the abscissa refers to procaine, cocaine and tropacocaine the lower to tetracaine and nupercaine

Heparin and Histamine in Mast-Cell Tumours from Dogs

The granular basophil cell of the tissues, the mast cell, has for long been thought to be the source of heparin[1]. Recently, it has been shown that the mast cell is also rich in histamine, a suggestion first made on histological grounds[2] and afterwards confirmed by the finding of a strong positive correlation for mast cells and histamine in a wide variety of normal and pathological tissues[3]. However, up to the present, the only comparative study of mast cells for heparin and histamine in the *same* starting material has been carried out on normal ox lung, in which the pleura especially yielded high values for all three[4]. It is thus of some interest that we have recently obtained six cases of subcutaneous mast cell tumour from dogs for estimation of their heparin and histamine contents.

As described elsewhere[3], tissue for histamine estimation was immersed as quickly as possible after removal in 10 per cent (v/v) trichloracetic acid for later extraction and assay on the standard guinea pig

Table 1. Histamine and Heparin Values of Six Cases of Subcutaneous Mast Cell Tumour from Dogs

Case No.	Breed	Age (yr.)	Sex	Site	Delay (hr.)	Duration (months)	Histamine (μgm./gm.)	Heparin (I.U./gm.)
I	Terrier	10	M	Flank	12	1·5	765	61·2
II	Terrier	7	M	Perianal	0	6	500	147·2
				(recurrence)	0	2	790	54·2
III	Golden cocker spaniel	10	F	Flank	0	2	1,290	110·0
				(recurrence)	3	2	650	357·0
IV	Golden Labrador	10	F	Leg	50	Unknown	7	130·0
V	Scottie	7	F	Leg	3	3	520	21·4
				(recurrence)	0	2	277	21·0
VI	Black Labrador	12	M	Thigh	48	24	550	174·0

ileum preparation or on the blood pressure of the atropinized cat, the specificity of the response in each case being confirmed by the use of mepyramine. Tissue for heparin estimation was placed at the same time in water containing a few drops of chloroform and was later digested with trypsin at *p*H 8 and assayed for anticoagulant activity by the method of Adams and Smith[5]. The results are presented in the accompanying tables. Table 1 lists the breed, age and sex of the dog and the site of its tumour. Of importance for the interpretation of the histamine values is the delay (shown in the sixth column) which elapsed between removal of the tumour and its preservation in trichloracetic acid. Attention has previously been directed to the progressive loss of histamine in small fragments of excised tissue exposed to air or immersed in water[3]. Table 2 gives average control values for histamine and heparin in a series of non-malignant tissues taken from normal or tumour-bearing dogs and placed at once in trichloracetic acid or chloroform water.

Table 2. Average Control Values for Histamine and Heparin in Non-malignant Tissues from Dogs

Tissue	Histamine (μgm./gm.)	Heparin (I.U./gm.)
Kidney	1	6·2
Lymph node	4	9·0
Spleen	5	7·2
Skin	9	11·0
Lung	25	12·8
Liver	25	19·7

It is necessary merely to glance at the tables to see that mastocytomas from dogs are in general exceedingly rich in both heparin and histamine, the low histamine value in case IV being no doubt due in part to the delay which occurred before this small specimen was treated with trichloracetic acid and in part to its having been sent to us wrapped merely in a swab moistened with formalin. A similar delay occurred with specimen VI: however, this was an exceptionally large tumour and only its comparatively fresh central portion was used for histamine assay 48 hr. later. The heparin values also showed considerable variation, and here it is of interest to observe that the tumours with the highest heparin contents were also those which contained the highest proportion of mast cells filled with strongly metachromatic granules. Indeed, when distant metastases were present, we found it possible to anticipate histological evidence of tumour mast cells in other organs by the demonstration of their raised histamine and heparin values.

Thus, so far as conditions in the dog are concerned, it is clear that not one but at least two highly potent pharmacological substances are present in the tissue mast cells—heparin and histamine.

Full details of these tumours will be published elsewhere.

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Photographs of Serial Sections of the Lung projected rapidly in Sequence using 16-mm. Film

The course and condition of small branching structures within a sample block of histological material cannot be appreciated with ease or demonstrated very successfully. With lung tissue, for example, casts and coloured, or radio-opaque, injections of the bronchial and vascular trees have been of great assistance; but these methods usually entail the removal or clearing of surrounding structures. Alternatively, serial sections may be observed *en masse* by serial reconstructions, thus overcoming, to some extent, the fact that the direct examination of serial sections in sequence is too slow for a full understanding of the plan of the tissue as a whole.

This communication describes a method for the visualization of a whole block of tissue histologically by introducing a regular short time interval between visual impressions of consecutive serial sections photographed on 16-mm. film. Preliminary trials with serial sections of rabbits' lungs have proved interesting.

There are two principal problems, the first being the inevitable loss of detail from the use of small frames of film. This disadvantage will vary with the type of material and the power of magnification, but in the present trials it has not been severe enough

to detract from the interpretation of the projected film. The use of 35-mm. film would improve the quality of the picture, but exceptionally fine detail is not necessary when differing histological appearances are presented in rapid succession.

The second problem is to match one section accurately to the next, and I have been fortunate in obtaining the use of a hand-operated Kodak ciné camera fitted with a sliding prism, which deflects the image to be photographed upon a ground-glass screen. The image of this screen was enlarged and projected on paper, giving a picture 9 cm. × 12 cm. The principal features of the image were drawn in pencil and erased after each change of field, and the intensity of the light was adjusted to give an exposure time of 5 sec. The open positions of the revolving shutter were marked against the positions of the crank for reference with each exposure. Test strips of negative film were developed in the laboratory and the final spliced strips were printed elsewhere.

Before film was used, a trial was made with a short series of consecutive sections photographed on 9 cm. × 12 cm. plates and matched by ink sketches on the ground-glass screen. Prints were mounted on cards and it was found that four changes of section each second could be followed satisfactorily. This rate was used in the film, four frames being exposed for each tissue section (film speed, 16 frames/sec.).

The film sequence could not be presented in motion from the start. The projection of the first of the serial sections was maintained for about five seconds to allow for the choice of a particular structure to be followed in the sequence. It was found necessary also to project the last section for the same length of time. Smoother sequence would be obtained using very thin serial sections, but vessels in the lung are easily disturbed when cut and a thickness of 7 μ (melting point of wax, 58° C.) was needed to avoid most of this displacement. Lung tissue tends to become stretched and distorted when cut and mounted in paraffin wax. This was not obvious until the film was projected, when these defects were seen to interfere, to some extent, with the smooth sequence of section detail. The use of a firmer embedding medium may solve this problem. A whole sequence was spliced in ring form and could be repeated until all the features of the film had been assimilated. One sequence was prepared from sixty transverse sections (7 μ thick) along the course of a branch of a lower lobe bronchus in the undistended lung of a rabbit, and it was possible to trace the lumen of a small bronchus through several branches down to the related air sacs in 15 sec. The mode of branching of pulmonary arteries and their relations to branching bronchi were well shown, as also was the distribution of collections of lymphoid tissue.

The further application of this method to the study of lungs and other organs, normal or abnormal, should assist both in the evaluation of serial section material in general and in its presentation for teaching purposes.

I wish to thank Prof. Geoffrey Hadfield for his advice.

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Radio Emission from the Andromeda Nebula

Observations have been made at a wave-length of 3·7 m. with interferometers of different resolving powers to determine the distribution of radio brightness across the Andromeda nebula, *M*31, which has also been investigated at radio wave-lengths by Hanbury Brown and Hazard[1]. When observations are made with small movable aerials, errors are caused by reception of radiation from adjacent radio stars. Good discrimination was therefore obtained with the present measurements by using several different sections of the large Cambridge radio telescope[2], although this method reduced the number of different axes and aerial spacings available. The relationship of the four axes used to the Andromeda nebula is shown in Fig. 1.

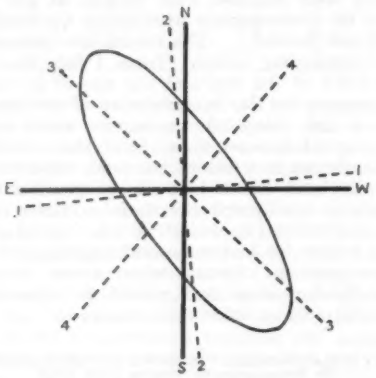

Fig. 1. Relationship of the interferometer axes to the Andromeda nebula

Column 1 of Table 1 gives the recorded amplitude expressed as a fraction of the amplitude for zero spacing, the total intensity of the source, which was found to be $2{\cdot}0 \times 10^{-24}$ watts.m.$^{-2}$(c./s.)$^{-1}$.

The strip distribution of radio brightness projected on axis 1 is shown in Fig. 2, together with the strip distribution of the optical emission from *M*31, of the mass as derived by Wyse and Mayall[3] and of the expected distribution of radio brightness calculated using the same model as that derived by Westerhout and Oort[4] from radio measurements on our own galaxy. The recorded amplitudes which would be expected from the models of Wyse and Mayall and Westerhout and Oort are shown in columns 2 and 3 of the table.

From Fig. 2 and from a comparison of the amplitudes for the axes 2 and 3, it can be concluded that the source of radio emission extends to radial distances

Table 1

Axis 1				Axis 2			
Aerial spacing	1	2	3	Aerial spacing	1	2	3
6 λ	0·96±0·1	0·95	0·98	14 λ	0·35±0·15	0·56	0·70
9 λ	0·84±0·1	0·91	0·94	Axis 3			
12 λ	0·50±0·15	0·88	0·89	18 λ	0·22±0·1	0·37	0·54
18 λ	0·20±0·1	0·70	0·80	Axis 4			
				18 λ	0·22±0·1	0·87	0·90

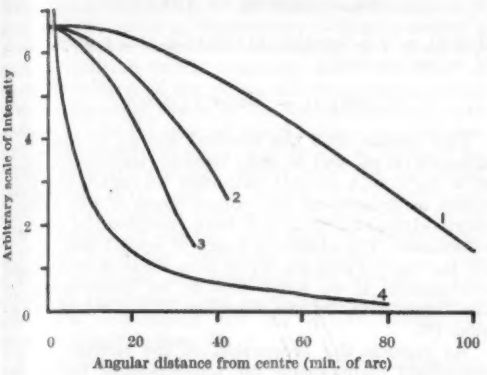

Fig. 2. The strip distributions, projected on axis 1, of: (1) the experimental determination of radio brightness; (2) Wyse and Mayall model; (3) Westerhout and Oort model; (4) the optical emission

in the plane of the nebula which are considerably greater than either of the models. Further, examination of the figures for axis 4 shows an even greater discrepancy between the observed and derived figures; the observations indicate that the radio emission also extends to very great distances normal to the plane of the nebula. The existence of such a distribution of sources is of considerable importance.

Westerhout and Oort[4] showed that it is only possible to explain the observed distribution of radio emission from the galaxy in terms of sources distributed like common stars if an isotropic component is subtracted from the observed values. They concluded that this component is probably of extragalactic origin, a possibility which has been discussed further in a paper by Shakeshaft[5]. The present observations suggest that, in fact, most of this component may be due to the existence of galactic radio sources distributed to great distances from the plane of the galaxy.

In order to make an estimate of the magnitude of this component, and in the absence of more detailed information, it is convenient to interpret the present observations in terms of two separate populations of radio sources: (*a*) a distribution similar to that proposed by Westerhout and Oort, which contributes about a third of the total intensity; (*b*) a distribution which has approximately spherical symmetry and extends to radial distances greater than 10,000 parsecs and which contributes about two-thirds of the total intensity. With this model it can be shown that an observer in the plane of *M*31 at a radial distance corresponding to that of the solar system would find a brightness temperature in the direction of the poles of about 200° K. at a wave-length of 3·7 m.

In order to make an estimate of the polar intensity which might be produced by such a population of sources in our own galaxy, it is convenient to suppose that the compositions of the two galaxies are identical; the relative intensities in the polar directions will therefore be related to the total power radiated by the two galaxies. Westerhout and Oort showed that the total intensity to be expected from the concentrated population of our own galaxy at the distance of *M*31 would be 2×10^{-24} watts.m.$^{-2}$(c./s.)$^{-1}$ at 3·7 m. when corrected for the new distance scale. It has been found that the flux associated with this population in *M*31 is approximately $0{\cdot}7 \times 10^{-24}$ watts.m.$^{-2}$(c./s.)$^{-1}$. It therefore seems possible that the extended population of radio sources in our own galaxy might produce a polar brightness temperature of about 600° K., a figure which is comparable with the observed value of 950° K. [6].

The observations of the Andromeda nebula have suggested the existence of a hitherto unexpected population of radio sources; a similar population in our own galaxy might also account for a large part of the so-called 'isotropic' component of cosmic radio emission.

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Recession of the Galaxies in Eddington's Theory

The first important formula in Eddington's "Fundamental Theory" (Cambridge, 1946) is (p. 6)

$$R_0/\sqrt{N} = 2\sigma, \qquad (1)$$

where R_0 is the radius of an Einstein universe, N the number of particles and σ the uncertainty constant of the physical origin. Einstein's formula for the total mass, considered as equivalent to $\frac{1}{2}N$ hydrogen atoms each of mass m, gives the independent relation (p. 10):

$$R_0/N = \gamma m/\pi c^2 = 3{\cdot}95 \times 10^{-53} \text{ cm.} \qquad (2)$$

From (1) and (2):

$$R_0 = (2\sigma)^2/3{\cdot}95 \times 10^{-53}, \qquad (3)$$

and Eddington finds Lemaître's limiting speed of recession of the galaxies, $V_0 = c/(R_0\sqrt{3})$, to be 572 km./sec. per megaparsec. For this "most accurate" determination, he uses in (3) his formula for $1/\sigma$ as a numerical multiple of the Rydberg constant. The 'observed' recession-factor he estimated (1944) to be 560 km./sec. per megaparsec, in agreement with his result.

In reviewing this book, I noted one[1] error, which occurs on p. 5 just before the result (1) above; this implies that in (1) 2σ should be 3σ. Thus the value of R_0 in (3) should be multiplied by 9/4 and V_0 by 4/9; the same change applies to his determination $V_0 = 585$ based on proton–proton scattering. This change is not in conflict with recent astronomical observation; for Baade has found[2] that current estimates of the distances of the galaxies should be doubled, so that the recession factor should be halved.

Amending equation (1) spoils the good agreement of N with Eddington's purely theoretical value $\frac{3}{2} \times 2^{256} \times 136$; but it does not affect his calculated values of the microscopic physical constants (in Chapters 2, 3, 9 and 11).

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Thermodynamics of the Two-Fluid Model of Liquid Helium II

The two-fluid model for liquid helium II first put forward by the late F. London[1] has been largely accepted as at least a very useful working hypothesis. There are, however, certain thermodynamical difficulties arising from this model which do not seem to have received an entirely satisfactory solution. For example, Gorter[2] has pointed out that an application of the phase rule leads to a unique triple point for the co-existence of the two fluids and the vapour phase, whereas, in fact, a whole range of such points is observed; and he has suggested that this may be explained by assuming that the Gibbs function for the fluids and vapour is not linear in the concentrations.

In this communication an alternative explanation of this anomaly is put forward based on the hypothesis that there is chemical equilibrium between the normal and superfluid components. This hypothesis seems reasonable, if not inevitable, since whatever the exact mechanism of the transition from the normal to the superfluid component, the very fact that such a transition does take place under changes of temperature (and pressure) would seem to imply some sort of chemical equilibrium between the two components for any given state of the liquid. Suppose, then, that U is the internal energy of a mass m of the liquid of volume V and entropy S, and let m_1 and m_2 be the masses of the normal and superfluid components, respectively. If we define the chemical potentials of the two components to be

$$\varphi_1 = \left(\frac{\partial U}{\partial m_1}\right)_{V,S,m_2}, \quad \varphi_2 = \left(\frac{\partial U}{\partial m_2}\right)_{V,S,m_1},$$

then for a general infinitesimal reversible change:

$$\mathrm{d}U = -p\mathrm{d}V + T\mathrm{d}S + \varphi_1\mathrm{d}m_1 + \varphi_2\mathrm{d}m_2. \qquad (1)$$

If u, s, and $1/\rho$ are the specific energy, entropy and volume, respectively, equation (1) may be written:

$$\mathrm{d}u = (p/\rho^2)\mathrm{d}\rho + T\mathrm{d}s + \varphi_1\mathrm{d}c_1 + \varphi_2\mathrm{d}c_2, \qquad (2)$$

where

$$c_1 = m_1/m, \; c_2 = m_2/m.$$

Since

$$c_1 + c_2 \equiv 1,$$

we have:

$$\mathrm{d}u = (p/\rho^2)\mathrm{d}p + T\mathrm{d}s + (\varphi_1 - \varphi_2)\mathrm{d}c_1. \qquad (3)$$

But the condition for chemical equilibrium between the two components is expressed by $\varphi_1 = \varphi_2$, since mass is conserved in the transition between the two components. Therefore:

$$\mathrm{d}u = (p/\rho^2)\mathrm{d}\rho + T\mathrm{d}s; \qquad (4)$$

that is, u is a function $u(\rho,s)$ of ρ and s only. But $U = mu$, so that:

$$U = mu(\rho,s) = mu(m/V, S/m). \qquad (5)$$

This means that the internal energy of the fluid depends on m_1 and m_2 only through the combination $m = m_1 + m_2$; so that, although we regard the bulk liquid as containing two components, it will behave thermodynamically as if it were composed of a single substance. The observed range of equilibrium points for the vapour and the liquid then finds an immediate explanation if we allow this to be determined, on the liquid side, by the function $U(V,S,m)$ of equation (5).

As regards the proportion of the normal to the superfluid components for temperatures below the λ point, the thermodynamics has apparently no prediction to make unless some further hypothesis is made. This is not surprising, however, since the theory developed in this communication would clearly be applicable to any equilibrium mixture of two isomeric components. In this connexion, a comparison with the theory of allotropy put forward by A. Smits[3] might be of interest.

Finally, we notice that additional support for the hypothesis here put forward is offered by the following derivation of the formula for the thermo-mechanical effect. Suppose that two separate masses of liquid helium II are connected by means of a very fine capillary tube. On the assumption that only the superfluid can pass along this capillary, the condition for both masses to be in equilibrium states is that the chemical potential of the superfluid component should have the same value in each. But from equation (5) it follows that the chemical potential of the superfluid component is given by:

$$\left(\frac{\partial U}{\partial m_2}\right)_{m_1,S,V} = \left(\frac{\partial U}{\partial m}\right)_{m,S,V} = g, \qquad (6)$$

where g is the Gibbs's function per unit of mass of the bulk fluid, namely:

$$g = u - sT + p/\rho. \qquad (7)$$

Therefore, the equilibrium condition for the two connected masses A and B is

$$g_A = g_B. \qquad (8)$$

If, now, the states of the two masses differ only slightly, the equilibrium condition becomes

$$\delta g = 0, \qquad (9)$$

that is,

$$-s\delta T + \delta p/\rho = 0, \qquad (10)$$

and

$$\delta p/\delta T = \rho s,$$

which is the accepted formula for the thermo-mechanical effect first derived by H. London[4] on the assumption that the superfluid component has zero entropy.

It is clear that the derivation of the formula for the thermo-mechanical effect just given should apply, in theory at least, to any equilibrium mixture of two isomers divided into two masses separated by a membrane permeable only to one of the two components. It is difficult, however, to see how the theory could apply in practice to any mixture apart

from liquid helium II, or an analogous substance, if such exists; since a temperature difference across a semi-permeable membrane separating two masses of such a mixture would normally lead to a flow of heat, by means of the permeable component, which would ultimately result in the disappearance of this difference. In the case of liquid helium II, however, where the semi-permeable membrane is replaced by a fine capillary through which only the superfluid component may pass, a continuing temperature difference is possible because the superfluid, having zero entropy, is entirely incapable of transporting any heat from one container to another. If this analysis is correct, the supposed zero entropy of the superfluid component has a practical rather than a theoretical importance for the thermo-mechanical effect in liquid helium II.

Note added in proof. The more general relationship $(\partial p/\partial T)_B = \rho s$ may be derived immediately from equation (8) by varying conditions in A while keeping those in B constant.

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May 7.

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Molecular Weight and Volatility

I wish to direct attention to the fundamental effect of molecular mass on volatility, since it does not support the widely accepted view that volatility decreases with increase in molecular weight. The latter view relies on the various *empirical* relationships between molecular weight and boiling point, but it has no theoretical basis. Indeed, detailed arguments will be presented elsewhere suggesting that these empirical relationships are fortuitous and that the apparent increase in boiling point with molecular weight is due to other causes. By contrast, the *fundamental* effect of mass on volatility has a theoretical background and affords a rational explanation of certain boiling-point 'anomalies'.

The fundamental effect is clearly revealed by the comparison of vapour pressures of compounds differing only in isotopic composition ('isotopic molecules'). These comparisons are least complicated by differences in intermolecular forces, and it can be assumed that differences in vapour pressures are due to the effects of mass alone. The relative vapour pressures of 'isotopic molecules' vary in a complex manner, and it is intriguing to find that the lighter species is not always the more volatile. In fact, the review by Clusius[1] of hydrogen and deuterium compounds shows that the relative vapour pressures vary with temperature in the sense that higher temperatures favour the volatility of the heavier species. Similar behaviour by other 'isotopic molecules' was reported by Urey[2] and Stokland[3]. However, this peculiar behaviour is explicable in terms of statistical thermodynamics[1,3,4] although a rigorous treatment seems to be confined to simple cases such as that given by Ubbelohde[5].

If this mass-effect is fundamental, then it should be a general phenomenon recognizable whenever vapour pressures of two compounds are compared. However, it is a second-order effect usually obscured by the greater effect caused by differences in intermolecular forces, and is only disclosed in favourable circumstances, for example, isotopic molecules. Nevertheless, a novel example of this phenomenon was recently reported by Bradley, Mehrotra and Wardlaw[6]. They found that some tetra-alkoxides of hafnium, $Hf(OR)_4$, were more volatile than the corresponding alkoxides of the lighter element zirconium, and preliminary vapour-pressure measurements showed the molar heats of vaporization of the tertiary amyloxides $M(OCMe_2Et)_4$ (M = Zr or Hf) to be practically equal. Clearly, because of the equalization of intermolecular attraction, due to shielding of the central atom, the fundamental effect of mass on volatility is being asserted in a 'super-isotope effect'. Moreover, this theory predicts a super-isotope effect as a general phenomenon occurring in centro-symmetric systems such as $M^{I}X_n$ and $M^{II}X_n$, where M^{I} and M^{II} are n-valent elements with nearly identical atomic radii and X is a univalent shielding group. Besides zirconium and hafnium, it seemed likely that compounds of niobium and tantalum and also molybdenum and tungsten might fulfil these conditions. A survey of the literature revealed that this is indeed the case, as is shown in Table 1, which gives data for pairs of compounds in which the heavier species is the more volatile.

Table 1

	NbF_5 : TaF_5 (ref. 7)		$NbCl_5$: $TaCl_5$ (ref. 8)		MoF_6 : WF_6 (ref. 9)	
Formula weight	187·9	275·9	270·2	358·2	210·0	297·9
Boiling point, ° C.	234·9	229·2	254·0	239·3	35·0	17·5
Radius of central atom (A.) (ref. 10)	1·34	1·34	1·34	1·34	1·36	1·37
Molar heat of vaporization (k.cal./mole)	12·9	13·0	13·2	13·6	8·34	8·69

The relative boiling points of these 'anomalous' pairs are quite inexplicable in terms of the conventional empirical rule connecting volatility and molecular weight, yet this behaviour is expected on the basis of what is here proposed as the fundamental effect of molecular weight on volatility. This theory will be presented in full elsewhere; meanwhile, experimental work is proceeding to test further these ideas.

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April 28.

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APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

DEMONSTRATOR/JUNIOR LECTURER IN ANATOMY—Prof. D. V. Davies, Anatomy Department, St. Thomas's Hospital Medical School, London, S.E.1 (August 19).

ASSISTANT, Grade A (with a special mathematics degree, or a general honours degree, including pure and applied mathematics, or an engineering honours degree including mathematics), IN THE MATHEMATICS DEPARTMENT—The Clerk to the Governors, Woolwich Polytechnic, London, S.E.18 (August 21).

LECTURER (preferably with a special interest in the strength of materials) IN THE DEPARTMENT OF MECHANICAL ENGINEERING—The Registrar, The University, Liverpool (August 21).

SCIENTISTS (with a good honours degree, or equivalent, in engineering or physics, and some relevant postgraduate experience in any of the following fields—light engineering development, pneumatic and/or hydraulic mechanism design, design of light electro-mechanical mechanisms, optical mechanisms), in the Central Research Establishment II of the National Coal Board, Isleworth, Middlesex, for work concerned with the study of methods of establishing suitable instrumentation for use in mines, and to design, develop and prove instruments required in all aspects of mining, and research into mining techniques—The National Coal Board, Establishments (Personnel), Hobart House, Grosvenor Place, London, S.W.1, quoting TT/815 (August 26).

GEOLOGISTS (with a university degree, preferably with honours, or equivalent, with all the subjects of geology at third year standard; or other such qualifications and experience as considered suitable), and GEOPHYSICISTS (with a university degree, preferably with honours, or equivalent, with a major (three year) pass in geophysics, physics, geology, mathematics or other appropriate subject) in the Department of National Development, Commonwealth of Australia, for work with the Bureau of Mineral Resources—The Senior Representative, Department of National Development, Australia House, Strand, London, W.C.2 (August 27).

SENIOR SCIENTIFIC OFFICER (with a first- or second-class honours degree in physics or chemistry, and at least three years subsequent experience), to carry out operational research in the field of radiation protection, develop specialized methods of identification and measurement of radioactive contaminants and apply the results to the practical control of radiation hazards in laboratories and plants—The Establishment Officer, Atomic Energy Research Establishment, Harwell, Berkshire, quoting 2/103/110 (August 27).

LECTURER (with experience in the field of interconnected power systems) IN ELECTRICAL ENGINEERING, at the University of Sydney, Australia—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (Australia, August 28).

ASSISTANT IN BOTANY—The Secretary of University Court The University, Glasgow (August 31).

LECTURER IN THE DEPARTMENT OF BACTERIOLOGY—The Secretary, The University, Edinburgh (August 31).

ASSISTANT LECTURER (with an honours special degree in geography) IN GEOGRAPHY—The Secretary, Bedford College, Regent's Park, London, N.W.1 (September 1).

DEMONSTRATOR IN GEOLOGY—The Registrar, The University, Nottingham (September 4).

RESEARCH ASSISTANT (with a good honours degree in botany, chemistry or biochemistry, and with experience of handling and growing micro-organisms) IN THE DEPARTMENT OF BOTANY, to work on the metabolism and photosynthesis of micro-organisms—The Secretary, University College London, Gower Street, London, W.C.1 (September 4).

SENIOR LECTURER IN ENGINEERING, and LECTURERS (2) IN ENGINEERING—The Registrar, The University, Manchester 13 (September 4).

DEMONSTRATOR or LECTURER IN PHARMACOLOGY—The Registrar, The University, Leeds 2 (September 6).

LECTURER or ASSISTANT LECTURER (with qualifications and experience in chemical engineering or a branch of chemical technology), IN THE DEPARTMENT OF CHEMISTRY, University College of the West Indies—The Secretary, Inter-University Council for Higher Education in the Colonies, 1 Gordon Square, London, W.C.1 (September 11).

LECTURER (with an honours degree and some practical experience) IN MECHANICAL ENGINEERING—The Registrar, The University, Leeds (September 13).

SENIOR SCIENTIFIC OFFICER (with a first- or second-class honours degree in metallurgy or equivalent qualification, and at least three years postgraduate metallurgical research experience) at the Ministry of Supply London Headquarters, to assist in research and development work on metals and their alloys for aircraft construction, and in the initiation and arrangement for experimental work in the Universities and Industrial Laboratories—The Civil Service Commission, Scientific Branch, 30 Old Burlington Street, London, W.1, quoting S.4364/54 (September 14).

READER IN ASIAN ANTHROPOLOGY at the School of Oriental and African Studies—The Academic Registrar, University of London, Senate House, London, W.C.1 (September 27).

ASSISTANT LECTURER (with special qualifications and interests in petrology) IN GEOLOGY—The Registrar, University College of North Staffordshire, Keele, Staffs (September 30).

LEVERHULME FELLOW AND LECTURER (with considerable experience of research work in nuclear physics, and preferably between the ages of 26 and 35 years) IN THE DEPARTMENT OF PHYSICS—The Registrar The University, Liverpool (October 16).

CHAIR OF AGRICULTURE at Rhodesia University College—The Secretary, Inter-University Council for Higher Education in the Colonies, 1 Gordon Square, London, W.C.1 (October 18).

ASSISTANT LECTURER IN THE DEPARTMENT OF CHEMISTRY, Makerere College, University College of East Africa—The Secretary, Inter-University Council for Higher Education in the Colonies, 1 Gordon Square, London, W.C.1.

BIOCHEMIST or ORGANIC CHEMIST, Experimental Officer or Assistant Experimental Officer grade in the Insecticides Department, to assist in work on insect biochemistry in relation to the mode of action of insecticides—The Secretary, Rothamsted Experimental Station, Harpenden, Herts.

CHEMISTS, Scientific Officer grade (with a first- or second-class honours degree or equivalent in chemistry, and with research experience, preferably in physical chemistry), at various research stations of the Ministry of Supply, mainly in the south of England—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26–28 King Street, London, S.W.1, quoting F.546/54A.

DEPARTMENTAL RESEARCH ASSISTANT (with a degree in physics or chemistry) to develop and maintain techniques applied to the investigation of macromolecules in solution (for example, sedimentation, diffusion, light scattering, etc.)—Dr. P. Johnson, Department of Colloid Science, The University, Cambridge.

FISHERIES OFFICER (with an honours degree in a natural science, with an emphasis on biology) in H.M. Colonial Service, Nigeria, to carry out applied and operational research into peasant fish culture—The Director of Recruitment, Colonial Office, Great Smith Street, London, S.W.1, quoting BCD.65/14/01.

LECTURER IN EDUCATION at the University of Malaya, Singapore—The Secretary, Inter-University Council for Higher Education in the Colonies, 1 Gordon Square, London, W.C.1.

PRINCIPAL SCIENTIFIC OFFICER (with a first- or second-class honours degree in chemistry, or equivalent qualification, together with many years research experience in applied chemistry), to direct and supervise the work of a Materials Development and Advisory Section—Senior Recruitment Officer, Atomic Weapons Research Establishment, Aldermaston, Berkshire, quoting 201/W.G.E./2.

RESEARCH ASSISTANT (with a good honours degree in geology preferably with emphasis on mineralogy, petrology or structural geology) IN THE DEPARTMENT OF GEOLOGY—Head of Department, Department of Geology, University College, Science Buildings, Merrion Street, Dublin.

RESEARCH FELLOW (graduate in zoology or veterinary science, and prepared to undertake teaching duties as well as research) in PARASITOLOGY in the Faculty of Veterinary Science—The Registrar, University of Queensland Brisbane, Queensland, Australia.

SOIL CONSERVATION OFFICER (with a degree in agriculture, and at least five years experience of the principles and practice of soil conservation), in the Agricultural Department, Nigeria, for duties which will include the design and layout of soil conservation schemes and the training of staff (Ref. BCD.63/14/025); and an AGRONOMIST (with a degree in agriculture or a related subject, and preferably with postgraduate research or advanced field experience and some experience of simple surveying), in the Somaliland Protectorate, to supervise agricultural experimental work with special reference to dry farming under semi-arid conditions, and to develop, in co-operation with a Hydrologist and Soil Surveyor, flood irrigation experimental pilot schemes, etc. (Ref. BCD.63/5/04)—The Director of Recruitment, Colonial Office, Great Smith Street, London, S.W.1, quoting appropriate Ref. No.

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Winchester College Natural History Society. Report 1950–53. Pp. 46 (Winchester: Winchester College Natural History Society, 1954.) [29

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